भारत सरकार
अन्तरिक्ष विभाग
सतीश धवन अंतरिक्ष केन्द्र
शार
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Government of India
Department of Space
Satish Dhawan Space Centre
SHAR
SRIHARIKOTA P.O. 524124, AP, INDIA
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TENDER NOTICE NO. SDSC SHAR/HPS/PT/14/2013-14

On behalf of President of India, Head Purchase and Stores, SDSC SHAR, SRIHARIKOTA invites sealed quotations for the following:

Sl No	Ref. No.	Description	Qty.	Tender Fee
01	SHVA 2013 00 2089 [TWO part basis]	Technical Services for Realisation of Civil, Electrical, Air-Conditioning, Equipment and other related services for Second Vehicle Assembly Building at SDSC SHAR, Sriharikota	**1 Lot**	**₹.230/-**
02	SHRO 2013 00 2163 [TWO part basis]	Facility Management for Technical Services for Network and system Administration for the period of two years from 01.04.2014 to 31.03.2016 at SDSC SHAR, Sriharikota	**1 Lot**	**₹.230/-**

Last Date for issue of tender documents : 27.12.2013 at 16:00 Hours
Due Date for receipt of tender : 30.12.2013 at 15:00 Hours
Tender Opening Date : 30.12.2013 at 15:30 Hours

Instructions to Tenderers:

For full details/scope of work and terms and conditions etc., please see the enclosed annexures.

1. Tender documents can be had from Sr. P & SO, Purchase, SDSC SHAR, Sriharikota –524 124, SPSR Nellore Dist. A.P.
2. Tender Fee shall be paid in form of CROSSED Demand Draftonly. The Demand Draft should be in favour of Accounts Officer, SDSC-SHAR drawn on State Bank of India, Sriharikota. The Tender Fee is NON-REFUNDABLE. Your request letter along with Tender Fee may be addressed to the Sr. Purchase& Stores Officer as indicated above.
3. Interested tenderers may, at their option, download the tender documents from the ISRO website www.isro.org&www.shar.gov.in and submit the offer along with the prescribed tender fee as per details given in the tender notification.
4. While requesting for Tender Documents, please superscribe on the cover as “Request for Tender document against Tender Notice No.**SDSC SHAR/HPS/PT/14/2013-14**
5. Quotations received after the due date/time will not be considered.
6. While sending sealed quotation/offer, superscribe respective Tender Number and Due Date on the envelope.
7. SDSC-SHAR, Sriharikota is not responsible for any postal delays/loss of documents in transit.
8. Head, Purchase and Stores, SDSC-SHAR, Sriharikota reserves the right to accept or reject any/or all the quotations in part or full.

DT: 26.11.2013

HEAD, PURCHASE AND STORES

REQUEST FOR PROPOSAL (RFP)

TECHNICAL SERVICES FOR

SECOND VEHICLE ASSEMBLY BUILDING (SVAB) AND ASSOCIATED SYSTEMS

(Ref No. - SHVA 2013 00 2089)

SATISH DHAWAN SPACE CENTRE SHAR

SRIHARIKOTA – 524124,

SPSR NELLORE DT., A.P.

PROPOSAL DOCUMENT, CLARIFICATION AND ADDENDUM

Proposals are invited from the interested bidders for the enclosed scope of work in two part bid.

Part-1 technical and unpriced part of the work and Part-2 Priced commercial part.

TITLE OF THE PROJECT: SECOND VEHICLE ASSEMBLY BUILDING

TITLE OF THE PROPOSAL: "TECHNICAL SERVICES FOR SVAB AND ASSOCIATED SYSTEMS"

Last Date for issue of tender documents: 27.12.2013 at 16:00 Hours

Pre-bid meeting: 20.12.2013 @ 10:00 hrs (venue will be intimated later)

Due Date for receipt of tender: 30.12.2013 at 15:00 Hours

Tender Opening Date: 30.12.2013 at 15:30 Hours

Place of submission of tender documents: SDSC SHAR, Sriharikota

1.0. PROPOSAL DOCUMENT

1.1 One set of proposal Document along with the drawings is issued. Bidder shall sign and stamp each page of proposal as token of his acceptance and submit along with his offer.

1.2 Transfer of Proposal Document issued to one Bidder to another is not permissible.

1.3 Proposal Document shall remain the property of the Department and if obtained by one intending Bidder shall not be utilizable by another without the consent of the Department.

1.4 The proposal shall be completely filled in all respects and shall be tendered together with requisite information and Annexure. Any offer incomplete in any particulars is liable to be rejected.

1.5 If the space in the Proposal Document or any schedule or Annexure thereto is insufficient, pages shall be separately added. These shall be consecutively page-numbered and shall also carry the Proposal Document number and shall be signed by the Bidder and entered in the index for the Proposal.

1.6 The Proposal with a complete set of the Proposal Documents shall be enclosed in a sealed cover superscribed with name of work, Proposal notice number; addressed and sent by registered post to the Proposal Receiving Authority specified in the Letter Inviting Bid or put in the Proposal box designed for the Letter Inviting Bid.

1.7 The sealed Proposals shall reach the address mentioned in Letter Inviting Bid before the time limit specified in the Letter Inviting Bid.

1.8 The Proposal shall be opened on the date and time specified in the Letter Inviting Bid or as soon thereafter as convenient. Proposal not received in time shall not be considered.

1.9 Bidders shall set their quotations in firm figures and without qualifications of variations of additions in the terms of the Proposal Documents.

1.10 Proposal containing qualifying expressions such as “subject to minimum acceptance” or “subject to prior sale” or any other qualifying expressions or incorporating terms and conditions at variance with the terms and conditions incorporated in the Proposal Document are liable to be rejected.

1.11 ADDENDA /CORRIGENDA

Addenda/corrigenda to the tender document may be issued by SDSC SHAR prior to the date of opening of the tenders, to clarify or reflect modifications in the contract terms and conditions.

Such addendum/corrigenda will be distributed to each firm or person who had purchased the tender documents.

1.12 AMBIGUITY

Should there be any ambiguity or doubt as to the meaning of any of the tender clause/condition or if any further information is required, the matter shall be immediately brought to the notice of Head, Purchase & Stores, SDSC SHAR in writing.

2.0. PREPARATION OF BIDS

2.1 Site Visit

Bidder is advised to visit and examine the site and its surroundings to familiarize himself of the existing facilities and environment and shall collect all other information which he may require for preparing and submitting the Bid and entering into the contract. Claims and objections due to ignorance of existing conditions or inadequacy of information will not be considered after submission of the Bid and during implementation.

2.2 Validity of offer

Bid shall remain valid for acceptance for a period of 6 (six) months from the due date of submission of Bid. The Bidder shall not be entitled during the said period to revoke or cancel his Bid or to vary the Bid except and to the extent required by the Department in writing. Bid shall be revalidated for extended period as required by the Department in writing. In such cases, unless otherwise specified, it is understood that validity is sought and provided without varying either the quoted price or any other terms and conditions of Bid finalized till that time.

2.4 Cost of Bidding

All direct and indirect costs associated with the preparation and submission of Bid (including clarification meetings and site visit, if any), shall be to Bidder's account and the Department will in no case be responsible or liable for those costs, regardless of the conduct or outcome of the Bid process.

2.5 Applicable Language

The Bid and all correspondence incidental to and concerning the Bid shall be in the English language. For supporting document and printing literature submitted in any other language, an accurate English translation shall also be submitted.

Responsibility for correctness in translation shall lie with the Bidder.

2.6 Arrangement of Bid

The Bid shall be neatly presented on white paper with consecutively numbered pages. It shall not contain any terms and conditions which are not applicable to the Bid.

The Bid and all details submitted by the Bidder shall be signed and stamped on each page as token of acceptance by a person, legally authorized to enter into agreement on behalf of the Bidder. Corrections/ alteration, if any, shall also be signed by the same person. Bidder shall submit Power Of Attorney in favour of the person who signs the Bid and subsequent submissions on behalf of the Bidder.

Department will not be bound by any Power Of Attorney granted by the Bidder or changes in the constitution of the firm made subsequent to submission of the Bid of after the award of the contract. He may, however, recognize such Power Or Attorney and changes after obtaining proper legal advice, the cost of which will be borne by the Bidder.

The cancellation of any document such as Power Of Attorney, partnership deed etc. shall be communicated by the Bidder to the Department in writing well in time, failing which Department shall have no responsibility or liability for any action taken by Contractor on the strength of the said documents.

Shall the Bidder have a relative or relatives or in the case of firm or company one or more of its shareholders or a relative or relatives of the shareholder(s) employed in a senior capacity in Department's organisation, the authority inviting Bids shall be informed of the fact at the time of submission of the Bid

2.7 Schedule Of Prices

The schedule of prices shall be read in conjunction with all the sections of proposal document.

For Lumpsum contract, the lumpsum prices quoted by the Bidder shall be firm and fixed for the completion of the work, unless stated otherwise. The price shall be filled in the format for 'Prices' –in section 13 of this document

2.8 Documents Comprising The Bid

Bids shall be arranged in the following order.

Part-1 Technical and Unpriced Bid

Bidder shall submit the detailed proposal under various options say Option-1, 2 etc. The details shall include the confirmation to the full scope of work as per the conditions stipulated in the RFP document.

Technical and unpriced commercial part shall comprise the attachments, specifying attachment number arranged in the order as follows:

(a) Submission of bid letter along with one set of proposal document duly signed and stamped as token of acceptance

(b) Power of attorney in favour of authorized signatory of the bid / proposal documents.

(c) All the annexure enclosed in proposal duly filled, signed and sealed

(d) Unpriced copy of schedule of prices with all other commercial terms and conditions duly filled (Prices to be kept blank), signed and stamped

(e) Data sheets for all the equipment & checklists enclosed in proposal duly filled, signed, & stamped.

(f) Technical details, equipment general arrangement drawings with part list, catalogue, layout drawings, P & I diagram, catalogues etc as applicable and any other drawing, document as mentioned in the proposal.

(g) Audited balance sheet including profit and loss account for last three financial years showing annual turn over

(h) Latest income tax clearance certificate.

(i) Latest solvency certificate from a scheduled bank.

(j) List of projects in hand & completed during last 3 financial year indicating the name of client, contract person, contract value, nature of work, work completed, work balance, name of Consultant, month & year of commencement & completion etc.

(k) Organisation chart for the proposed work with bio data of key personnel

(l) Bar chart.

(m) Execution Plan.

(n) Any other relevant document, bidder desires to submit.

The bid shall reach the Department before due date as specified in Tender document in a sealed cover.

Part-2 Price Commercial Bid

Supplier shall submit the price bid in a separate sealed cover. The prices shall be quoted separately for each option, as per the table given in RFP document (Refer Section 13 – price)

Priced commercial bid shall contain schedule of prices duly filled in, signed and stamped. No deviations, terms and conditions, assumptions, conditions, discounts etc. shall be stipulated in price bid. Department will not take cognisance of any such statement and may at their discretion reject such bids.

3.0. BID SUBMISSION

Bids duly filled in by the Bidder shall invariably be submitted as stipulated in the Letter inviting bid.

Bids shall be submitted in the following manner, in separate sealed envelopes duly subscribed as below :

Part – I Techno-Commercial Part Of The Bid For The Work

Envelope shall be marked with following:

PART-I TECHNO-COMMERCIAL BID

Name of client: Indian Space Research Organisation, SDSC, SHAR

Title of the project: Second Vehicle Assembly Building

Title of the proposal: "Technical Services for SVAB and Associated Systems"

Due date and time of the opening:

From: (Name of the bidder with address)

This envelope shall comprise the original signed copy of the proposal document, drawings, addendum/corrigendum (if any), unpriced copies of schedule of prices, payment schedule and list of essential spares for 3 year trouble free operation. The deviation statement and checklist shall be filled in and enclosed, without which the bid will not be considered.

Part – II Price Part Of The Bid For The Work

Envelope shall be marked with following:

PART-II PRICE BID

Name of client: Indian Space Research Organisation, SDSC, SHAR

Title of the project: Second Vehicle Assembly Building

Title of the proposal: "Technical Services for SVAB and Associated Systems"

Due date and time of the submission:

This envelope shall comprise one original plus three copies of ”Schedule of prices”, “payment schedule” and “list of essential spares” duly filled in all respect. This envelope shall be sealed subscribing **“DO NOT OPEN”.** Any other terms and conditions given in this part shall not be considered and if insisted upon by the Bidder, bids are liable for rejection.

Both the Parts (i.e. Part I & Part II) prepared as described above shall be inserted in another envelope and marked with the following:

Title of the proposal: “Technical Services for SVAB and Associated Systems”

Due date and time for submission:

From: (Name of the bidders with address)

To: **Head, Purchase & Stores**
Satish Dhawan Space Centre SHAR
ISRO, Dept. of Space
Govt. of India
Sriharikota – 524124
SPSR Nellore Dist, Andhra Pradesh, India

a) Department may open Part – I of the bid on the due date of opening subject to meeting the minimum evaluation criteria. Price Bids (Part-II) of technically and commercially acceptable offers shall be opened at a later date.

b) Department reserves the right to reject any or all the Bids without assigning any reasons thereof.

4.0. BID EVALUATION

a) During evaluation, Department may request Bidder for any clarification on the bid, additional documents.

b) Techno-commercial discussion shall be arranged with Bidder, if needed. Bidder shall depute his authorised representatives for attending discussions. The representatives attending the discussions shall produce authorisation from his organisation to attend the discussion and sign minutes of meeting on behalf of his organisation if required. The authorised representative shall be competent and empowered to settle/decide on all technical and commercial issues.

c) The complete scope of work is defined in the Proposal document. Only those Bidders who undertake total responsibility for the complete scope of work as defined in the Proposal document shall be considered.

d) In case Bid does not fully comply to the requirement of Proposal document and the bidder stipulates deviations to the clauses of the proposal in Schedule of deviations, which are unacceptable to the Department, the Bid will be rejected.

e) Performance of Bidder on similar nature of works executed/ under execution shall be taken into consideration before selecting the Bidder for opening his price bid.

f) The time schedule for completion is given in the Proposal document. Bidder is required to confirm the completion period unconditionally.

g) If necessary, to arrive at evaluated prices, wherever applicable, loading on total quoted prices shall be done as detailed in the proposal document or as considered suitable by Department if not detailed in the proposal.

h) Department reserves the right to accept a bid other than a lowest and to accept or reject any bid in full or part without assigning any reasons. Such decisions by the Department shall bear no liability whatsoever consequent upon such decision.

i) The Bidder, whose bid is accepted by the Department, shall be issued a Letter of Intent (LOI) to proceed with the work. Bidder shall confirm acceptance by returning a signed copy of the LOI. Thereafter Department may issue purchase order or Department will sign the Contract with successful Bidder.

j) In case of foreign supplier, contract / purchase order will be released by Department and supplier shall forward the order acceptance and banker details within 10 days of receipt of contract / purchase order for establishing LC (Letter of Credit)

k) Department shall not be obliged to furnish any information / clarification to unsuccessful bidder as regard non acceptance of their Bids.

5.0. AMENDMENT TO PROPOSAL DOCUMENT

Department may, for any reason whether at his own initiative or in response to the clarification requested by the prospective Bidder, issue amendment in the form of addendum/corrigendum during the Bid period and subsequent to receiving the Bids. Any addendum/corrigendum thus issued shall become part of Proposal document. For addendum/corrigendum issued during the Bid period, Bidder shall consider the impact in his Bid. For addendum/ corrigendum issued subsequent to receiving the Bids, Bidder shall follow the instructions issued along with addendum/corrigendum.

6.0. PROCESS TO BE CONFIDENTIAL

Information related to the examination, clarification, evaluation and comparison of Bids and recommendations for award of contract shall not be disclosed to Bidder or other person not officially concerned with such process. Any effort by Bidder to influence the Department in processing of Bid or award decisions may result in rejection of such Bidder's offer.

7.0. DEPARTMENT'S RIGHT TO ACCEPT OR REJECT A BID

Department reserves the right to accept a Bid other than the lowest and to accept or reject any Bid in whole or part, to annul the Bid process or to reject all Bids with or without notice or reasons. Such decisions by Department shall bear no liability whatsoever consequent upon such decisions.

Technical Services for Second Vehicle Assembly Building (SVAB) and Associated Systems

8.0. INTRODUCTION

Satish Dhawan Space Centre SHAR (SDSC SHAR) is one of the units of Indian Space Research Organisation (ISRO), Government of India, which is located at Sriharikota Island, 100 Km north of Chennai. SDSC SHAR is planning to realise Second Vehicle Assembly Building (SVAB) and Associated Systems as a part of its expansion programme.

This document serves as an RFP to the scope of work of engineering services required for realising SVAB, which includes design, analysis and documentation of Civil, Mechanical, Structural, Electrical and Air Conditioning systems of SVAB. The broad specifications are given in Annexure-1

The interface requirements of various equipments and other design inputs etc., are to be mutually worked out and matched between system / facility to that of civil construction, electrical and A/C from Mechanical, Structural, Instrumentation and Process systems etc. during the course of design. Typical soil investigation data mostly applicable to SHAR will be provided by the Department for designing the critical civil structures. Certain inputs relevant to the design criteria are explained under the design features in the subsequent sections of the document.

9.0. SCOPE OF THE WORK OF TENDERER IN DIFFERENT PHASES

The scope of work of this tender covers the configuration, preliminary and detailed engineering, preparation of tender documents and certification of design changes during construction / fabrication of various systems of Second Vehicle Assembly Building and associated systems covering Civil, Mechanical, Structural, Electrical and Air Conditioning systems, twin rail track extension, Bogie & hauler for Mobile Launch Pedestal traction and Auxiliary Umbilical Tower including repositionable cryo arm as per the requirements and specifications given as Annexure-1 to this document.

The tenderer shall review and confirm the Department's specifications presented and clearly delineate any deviation from the specifications laid down with exhaustive reasoning. Once accepted, it is the Contractor's responsibility to configure and detail out the systems meeting the functional requirements as per the specifications and conditions stipulated in this document/contract.

For meeting the system specifications for certain items configuration proposed by the Department are brought out under several major systems. Tenderer is required to go through the configurations proposed by the Department and adopt suitable configurations or provide alternate configurations to meet the Department's specifications. In case, the configuration proposed by the Department is adopted, Tenderer shall elaborate further improvements if any and provide details, such as calculations with adequate reasoning and also assume full responsibility of the configuration to meet Department specification for its proper functioning and easy maintenance.

The scope of work shall be for conceptual & preliminary design, detailed design, optimization, structural analysis, model studies, preparation of fabrication drawings and preparation of tender specification documents by estimating bill of materials. Each phase of work to be presented to the expert review teams constituted by the Department and design / analysis documents to be updated as per the committee recommendations. The scope of work also includes certification of design changes during realization of systems.

The scope of technical services work includes the following:

Conceptual and Preliminary design	– Phase - I
Critical design / engineering & fabrication drawing preparation	– Phase - II
Preparation of tender specification documents	– Phase - III
Certification of design changes during fabrication/ construction	– Phase - IV

PHASE-I: CONCEPTUAL AND PRELIMINARY DESIGN

Phase-I commences immediately after the issue of letter of intent or date of signing of the contract. In this phase, the tenderer shall present concept and preliminary design of all the systems.

This phase of work shall be divided into two parts. The part-1 is the conceptual design which is followed by part-2, the preliminary design. In the part-1, all the options which have direct influence on the finalization of configuration, if any, shall be studied in detail and proceed on the meritorious one, for which preliminary design can be taken up. Part-2, preliminary design phase ends with the successful completion of Preliminary Design Review (PDR) by the Department and submission of documents as envisaged in the following section after incorporating Review Committee recommendations by the tenderer.

This phase-1 of work shall be completed within 4 months

Changes/modifications/improvements over the technical input, if any, at this stage, are to be presented to the Department with full justification and Department's approval obtained for such changes.

The Tenderer shall prepare the following details during Phase-I and submit the documents finally for review by the Department.

Part-1: Conceptual Design

The configuration document for all items/subsystems/systems shall be prepared by tenderer. The configuration document shall contain the following:

- Title
- Design inputs/Users requirements
- Configurations studied
- Material selection
- Trade off studies on configuration giving merits and demerits and comparison of configurations
- Preliminary specifications of major subsystems
- Schematic diagrams layout, plans, and cross sections at various locations
- Details of long lead items
- Configuration management plan
- Erection aspects
- Compliance / deviations to user specification

The Design Review Team will review the configuration of the items/ subsystems/systems. Any suggestion/modifications recommended by Review team shall be incorporated in the final configuration studies report.

Part-2: Preliminary Design

The Tenderer shall carryout preliminary design of items/subsystems/systems after conceptual design approved by Department and bring out design report along with the interface details related to this system for the items covered in the scope or for items related to other systems associated. The salient features covered under this phase of design are to be brought out for

major facilities. The tenderer shall consider all the features but not limited to as specified by Department.

The design drawings shall be prepared using AutoCad 2010 or later versions preferably using 3D solid model options.

Mechanical drawings in preliminary design stage shall show line diagrams of mechanical assemblies with specifications for bought out items.

The Preliminary Design for the specific work packages shall include the scope as detailed below:

CIVIL

- Finalization of building foundation indicating type, trade off studies, if any.
- Typical foundation design calculation.
- Structural scheme showing beams, columns/frames, slabs and reinforcement in the form of line diagrams.
- Typical joint details showing beam column junction.
- Details of plinth beam connection.
- Structural static analysis for SVAB with foundation to arrive at stress levels, deflected shapes for cyclonic winds and dynamic analysis. Earthquakes design checks as per relevant IS Codes.
- Analysis to meet thermal loads, buckling etc. shall be carried out.
- Design of sealing joints to avoid entry of rain water into building at doors/windows/openings etc.
- Grade of concrete, cover shall be considered for saline atmosphere as per latest IS 456-2000.
- Schedule of doors and windows.
- Finish details including painting of facilities.
- Testing requirements, if any.
- Construction philosophy with equipment and materials to be mobilized.
- Interfaces with electrical, A/C and other disciplines.

- Preparation of preliminary drawings furnishing RCC details, embedment location, opening, A/C duct etc.
- Inspection and testing procedures and scope of inspection of third party inspection agency/ Department for all bought out items.
- PDR document comprising of all the above shall be submitted for review and approval. Upon completion of PDR, and incorporation of all recommendations therein, the final PDR document shall be submitted.

MECHANICAL/ STRUCTURAL

- Preliminary sizing of structural members for all structures.
- Identification of detachable portions, selection of hinge points or support points and drive actuation points.
- Selection of drive system such as motor, gear box, coupling etc. in accordance with relevant standards.
- Structural analysis of the systems with proper boundary conditions.
- Arriving at the deflections in the structures for all loading conditions and load combinations and ensuring these within acceptable limits.
- Estimation of natural frequency for certain critical systems which are identified under Annexure-I. The other modes of excitation less than this frequency also shall be listed.
- Sensitivity analysis shall be carried out to study the effect of failure of a few structural members.
- Dynamic response of the overall structure shall be carried out for the operating conditions likely to be encountered.
- Estimation of local stresses at openings and cut outs and providing stiffeners to the structure.

ELECTRICAL

- Single line diagram for overall electrical system from sub-station to various facilities and also within the facilities from MV panel.
- Electrical load summary for individual facilities ie. Equipment loads, lighting load, A/C loads etc.

- Electrical equipment layout drawing for the entire facility including distribution drawings, schemes.
- Design of electrical system and specifications of major electrical equipments, components etc.
- Sizing of electrical equipment, cables, transformers etc.
- Electrical cable layout and cable schedule.
- Testing requirements.
- Realization philosophy
- Interfaces with civil, A/C and other disciplines.
- Voltage drop studies and analysis, fault level calculation
- Redundancy design, protection and study of single point failures

AIRCONDITIONING

- Heat load calculations.
- Quantities and major specifications of all the items like compressors, chillers, condensers, Air Handling Units, pipes, fittings, instruments; considering sizing, material compatibility, pressure rating, dimensions/ design standards etc.
- Conversion of finalized schematic diagram into a process & instrument diagram, consisting of all equipment, flow components instruments etc., and their inter-connecting pipeline for air conditioning system.
- Sizing of all pipelines based on pressure drop calculations and piping design.
- Finalization of insulation scheme for air conditioning system.
- Design of support, expansion joints for equipment, pipelines etc.
- Detailed specification of controller, I/O units and operator programming station.
- Redundancy requirements met at controllers, I/O units and at network level including the power supplies.
- Actual hardware and I/O requirements based on process requirements and their distribution with adequate spares.
- Procurement specifications of all equipment, flow components, instruments etc.

- Testing requirements.
- Realization and erection.
- Interfaces with Civil, Electrical and other disciplines.

EQUIPMENTS

On the completion of this phase, the Tenderer shall provide the specifications for the special bought-outs which are to be procured by the Department. Such systems include- hauler, elevators, EOT crane, gear boxes, hydraulic actuators etc.

The scope of the tenderer pertaining to the equipments and standard bought-out items will be completed in this phase.

Procurement of these items is initiated subject to clearance by Standing Design Review Committees of Department.

Details of documents to be supplied for Preliminary Design Review (PDR):

The PDR document shall contain for each system / sub-system:

- Back ground information
- Department's requirements
- Configuration studies
- Review committee suggestion
- Design inputs/specifications
- Design criteria
- Generation of wind profiles
- Tests
- Load combinations
- Basic sizing of members

Typical structural analysis shall include

- Detailed analytical model with descretising nodes, element numbers, etc.
- Software packages used

- Loading conditions considered with gross magnitude of individual load cases
- Deflections and stresses in critical zones in tabular forms for various conditions
- Support reactions
- Stress contour plots
- Dynamic analysis for critical systems viz, Cryo Arm & Bogie
- IS code checks wherever relevant
- Mode shapes
- Natural frequencies
- Stiffeners Analysis (P-Delta analysis)
- Schematic diagrams
- Layout
- Plans
- Cross sectional details
- Configuration management plan
- Reliability and Quality Assurance plan
- Bought out items specifications
- Interface details between items/subsystem/system
- Compliance of design specifications
- Fabrication criticalities
- Erection sequence
- Method of testing the systems for its specifications

The documents shall be supplied in ten sets of hard copies for the purpose of review.

PHASE-II: CRITICAL DESIGN/ ENGINEERING & FABRICATION DRAWING PREPARATION

Part- 1 Critical Design/ Engineering

Phase-II commences immediately after the completion of Preliminary Design Review. In this phase, the tenderer shall present design/development details of the system, sub-systems, major equipment including all external and internal interfaces. Specific handling procedures during installation and special fixtures, if any, shall also be identified.

The construction/ installation/ erection sequence is also frozen in this phase.

The Phase-II, Part-1 ends with the successful completion of the final design review by the Department and incorporation of the Review Committee recommendations. The tenderer shall prepare the following details during Phase-II and submit the documents finally for review by the Department.

CIVIL

- Indicating the realization tolerances for verticality and the location tolerances of embedments.
- Design of roof slabs, RCC walls, beams, RCC columns/ brackets, footing etc., the building.
- Design of equipment foundations, RCC pedestal cable trench etc., based on dead load and live load, cyclonic load, vibration load, acoustic load etc, wherever applicable.
- Ductile detailing of RCC elements as per IS 13920, to minimize seismic damage.
- Design of pits, collection tanks (underground), over head tanks etc. by considering appropriate treatment to avoid dampness, seepage, leakage etc.
- Design of embedment plates/ pipe supports/ structural support considering respective loads.
- Design of cable trench with supporting arrangement for cables including cover slab.
- Design of public health system for individual buildings.
- Design of water line for drinking water and other user as per requirement.
- Sizing and distribution network for process and drinking water needs at different buildings with independent lines from supply source.

MECHANICAL/ STRUCTURAL

- During the final design phase the joint details shall be worked out for all structural systems. Member details, Welding details, Weld qualifications surface preparation for corrosion prevention painting schemes shall also be worked out.
- For machined components, the design drawing shall indicate clearly the dimensional tolerance, Geometrical Tolerances. Heat treatment/stress relieving requirements, surface finishes to be achieved, surface protection by applying anti corrosive varnish shall be worked out.
- Procurement plan for indigenous items identifying source of supply, modality of supply, scope of supply etc.
- Assembly Tolerances for control assembly/Total assembly, Alignment accuracies, Trial run specification, performance under load specification, Type Test of items shall be worked out.
- Major sub- system interface details.
- Erection plan and procedures along with required material handling equipment including special equipment, if any.
- List of recommended spares for two years of trouble free operation.
- Identification of applicable standards and codes.
- Reliability and quality assurance plan.
- Safety implementation and control plan.
- Preparation of detailed design report for each sub-system and presentation of the same to Department for approval.

ELECTRICAL

- Switch gear single line diagram.
- Short circuit calculations and voltage drop calculations.
- Preparation of logic diagram and interlock diagrams.
- Inter panel connection diagram.
- Electrical cable tray and trenches layout.
- Emergency power layout.

- Grounding system design and drawings.
- Electrical loop sketches.
- Cabling and inter connection schemes between various facilities.
- Selection of painting scheme and application procedure.

AIR-CONDITIONING

- Erection plan, procedure and sequence along with required material handling equipment for electrical and A/C equipments.
- Design of Air Conditioning system and clean rooms considering heat load.
- Structural, thermal, flows and stresses analysis of Air Conditioning piping.
- Selection and procedure for Air Conditioning pipeline insulation.
- Air Conditioning duct design with insulation and routing within the building.
- Preparation of piping loop drawing for hydro test.
- Dimensions and actual numbers of racks and consoles for control system.
- Identification of I/O including spares, sub-system etc.
- Wiring details of I/O channel within racks and also between field instruments and I/O racks.
- Development of application software for control system of air conditioning system.
- Configuration procedures for system and application software at controller and operator station.
- Training to Department's representative on system software, configuration, application software etc.

The applicable IS standards; regulations for design, construction, fabrication, erection and testing shall be followed.

In case any particular aspect of the work is not specifically covered by any Indian standard, International standards or any other standard practice may be followed after obtaining approval.

A final design report shall be brought out with the following for each and every system / facility.

- Background information

- Review committee suggestions
- Compliance of review committee suggestion
- Finer analysis details of stress, Thermal and FMECA etc.,
- Unresolved specifications, if any
- Critical fabrication requirements
- Critical assembly requirements
- Supply standards incorporated in design
- Handling provisions for erection
- System integration plan
- Design margins available
- Operational and maintenance details
- List of wearing out components
- Test and evaluation procedure
- System acceptance standard
- Fabrication drawings
- Additional works suggested by Design review committee, if any

At the conclusion of this phase, the tenderer shall submit the final design document to the Department in ten sets of hard copies for each item.

Part-2 Fabrication/ Construction Drawing Preparation

Contractor shall follow the following guidelines in preparing and submitting fabrication / Construction drawings.

- The contractor shall start to submit progressively for approval, the fabrication/construction drawings based on the approved design drawings to form part of tender documents.
- All the drawings prepared and submitted shall have compatibility with AutoCad 2010 and documents shall have compatibility with Windows XP/Vista.
- Isometric 3D drawings in assemblies are also required to be submitted for interface checks.

- The detail fabrication drawings shall be drawn out in a neat and sequential manner with the details in appropriate scale so as to facilitate cross checking and shall preferably be according to the erection modules.
- Edge preparation details, welding and weld testing (NDT) shall be identified, requirements for preheating, inter pass heating, stress relieving and heat treatment procedure, wherever required, shall be clearly indicated in the drawings.
- The sequence of submission of fabrication drawings for approval shall match with the approved fabrication and erection schedule. The approval of the drawings will be accorded only towards the general conformity with the design requirements and ensure the correctness of functional requirements as well as specifications. Also to ensure the correctness of general arrangement for centreline dimensions, levels, section sizes and adequacy of connections including splice joints, the number of bolts, weld length, size of gusset/ end plates, etc. The correctness of all other details like cutting lengths, matching of holes, notch dimensions, match markings, bill of materials, bolt list etc., will be entirely the contractor's responsibility. The approval of the drawings however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The fabrication drawings preparation shall consider but not be limited to the following requirements.

a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.

b) Dimensional drawings of base plates, foundation bolt locations, additional members, mounting details of equipment supplied by the contractor covered under this contract or as shown in the design drawings.

c) Provide the next higher available section in case the specified section is not available and submit comparison sheets to show that the proposed alternative sections are as strong as the original sections shown on the design drawings.

d) Complete Bill Of Materials and detailed drawings of all sections and also their weights.

e) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

f) The drawings shall indicate the items of steel work that require pre/post heating including sequence of welding stress relieving and test required to be carried out on welds identified as per this specification

- The preparation of fabrication drawings shall not be sublet without prior approval of the Department.
- The drawings shall give all the necessary information for the fabrication, erection and painting of the steel work in accordance with the provisions of this Specification.
- The drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection.
- The drawings shall give complete information necessary for fabrication of the various components of the steel work, including the location, type, size and extent of welds. These shall also clearly distinguish between shop and field bolts and welds and specify the class of bolts and nuts.
- The drawings shall be drawn to scale large enough to convey all the necessary information adequately.
- Notes on the drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked up stresses and distortion.
- Wherever required backing strip at weld joints shall be in accordance with requirements of IS : 813 scheme of symbols for welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.
- Controlling dimensional tolerances and geometrical tolerances required as per design shall be bought out in fabrication drawing with proper details for inspecting the same.

The successful consultant shall be responsible for and shall pay for any alternations of the work due to discrepancies, errors of omissions on the drawings or other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the contract, provided that such discrepancies, errors or omissions are not due to inaccurate information or particulars on the inputs furnished to the contractor. In the latter case, the contractor will be paid for any alternation that has to be made after the materials have been fabricated by the contractor.

The successful consultant shall prepare process flow charts for all the fabricated and machined items sub assembly wise indicating process sequence, stages of inspection and care to be taken at different stages of process and shall be submitted to Department for approval.

At the conclusion of this phase, the tenderer shall submit three sets of drawings for review and approval by the Department

PHASE- III: PREPARATION OF TENDER SPECIFICATION DOCUMENTS

On completion of phase I, the contractor shall generate the Tender Specification Documents with detailed tender schedules based on which the Department can float tenders for the realization of systems covered under the scope. Hence Phase II and Phase III shall be paralelly carried out by the tenderer.

This phase will complete with submission of all the documents by the Tenderer after incorporating the comments, suggestions and recommendations by the Departmental Committees. The following documents in soft copies and fifteen (15) sets of hard copies for each item are to be generated and submitted to the Department.

- Configuration Design Document
- Preliminary Design Document
- Final/Critical Design Document
- Tender Specification Document
- Fabrication Drawings

PHASE- IV : CERTIFICATION OF DESIGN CHANGES DURING FABRICATION/ CONSTRUCTION

The contact shall remain active even until the completion of the realization of the Project. In this phase, the contractor shall be responsible to provide clarifications if a design change is envisaged in fabrication/ construction due to unexpected reasons.

10.0. RESPONSIBILITIES OF DEPARTMENT

1. Providing any clarifications to the user requirements prepared by the department and design criteria for finalising the designs.
2. Finalisation of building locations, orientation of buildings, roads layout, location of hume pipes and culverts across roads.
3. Finalisation of equipments locations inside the building

4. Providing the interface details for all systems which are not covered in the scope of work.
5. Approval of preliminary design, final design, construction and fabrication drawings.
6. Handing over the soil investigation report including the recommendations there in.
7. Department will initiate the procurement action based on the tender specifications / documents provided by the tenderer and place orders.
8. Department will provide rent free unfurnished office space for the tenderer to work inside the SDSC SHAR island. Telephone and fax may be provided on chargeable basis. Other office equipment and furniture to be mobilised by the tenderer.

11.0. RESPONSIBILITIES OF TENDERER

1. Completing the activities as per the scope of the work envisaged in the section 2 of the document.
2. Carry-out corrective engineering in the event of faulty design solely attributable to the tendered without any additional cost.
3. Obtaining clearance from the department at the end of each phase of scope of work as stipulated in the section 2 of the document.
4. Presenting the configurations / designs/ analysis results to the review committees constituted by the department and incorporating corrections before finalising the concerned phase of work.
5. Delivering the services as stipulated in the section.5 of the document.
6. Tenderer shall engage adequate number of technical staff to carryout the work with in the schedule.
7. Furnishing the office space and providing accommodation and logistics for representatives of the tenderer during their stay at SDSC SHAR.

12.0. SCHEDULE OF SERVICES

1.	Conceptual Design	T + 2 months
2.	Preliminary Design	T + 4 months
3.	Submission of Tender Specification Documents	T + 6 months
4.	Detailed Design & Fabrication drawing submission	T + 12 months
5.	Certification Of Design Changes During Fabrication/ Construction	T + 42 months

Note: T is the time of accepting the contract / signing the contract

13.0. PRICE

13.1 Technical Services as per the scope of work

Tenderer shall submit the price for the entire scope of work on lumpsum basis. All travel and incidental expenses incurred by the design team in the process of executing the full scope of work and participation in all the connected reviews will be inclusive of the lumpsum price.

Service	Basis of payment
Technical services for SVAB which includes Design Engineering (Conceptual, Preliminary, Detailed Designs), Preparation of tender documents and certification of design changes during fabrication / design	Lump sum

13.2 Additional Design Engineering Services

In case Department requires, the tenderer to perform additional design works not foreseen in the scope of work provided in the lump-sum price above, tenderer shall be compensated on a man day basis for different category of team members. The rates for such categories shall be quoted by tenderer separately as given in the table below.

Sl. No	Category	Experience	Man-day rate	Travel cost per trip
1	Lead Engineer	> 15 Yrs		
2	Sr. Engineer	> 10 Yrs		
3	Engineer	> 5 Yrs		
4	Drafts-Man	> 10 Yrs		

Payment Terms

The following major milestone payments may be applicable.

1. 10% of the total contract value as advance after acceptance of the contract against submission of Bank Guarantee

2. 25% against completion of preliminary design and submission of corrected documents on pro-rata basis
3. 30% against completion of Detailed design and submission of corrected documents on pro-rata basis
4. 30% after submission of tender specification documents on pro-rata basis
5. 5% after completing the contract period or completing the full scope of work.

The weightage for different packages for releasing the pro-rata payments against each mile stone no 2 to 4 will be mutually agreed and finalised with the successful bidder.

Mode Of Payment

In case of indigenous suppliers, all the payments due to Supplier shall be paid in Indian currency and by crossed "Account Payee" cheque sent to the registered office of the Supplier. bidders can submit the banker details and payments can also be sent through ECS.

14.0. VALIDITY

The offer shall be valid for 6 months from the date of opening of tender.

15.0. LIQUIDATED DAMAGES

In case there is a delay in the technical services by the tenderer beyond the contract period, tenderer is liable to pay Liquidated Damages for the uncompleted portion of the work at the rate of **0.5%** of the uncompleted work per week of delay subject to a maximum of **10%** of the total contract value. The break up of contract value for each phase of work can be mutually agreed upon after entering into the contract.

16.0. EXTENSION OF TIME

If the completion of deliveries of equipment, work is delayed due to reason of Force Majeure the Supplier shall without delay give notice to the Department in writing of his claim for an extension of time. The Department on receipt of such notice may agree to extend the Contract period or delivery date as may be reasonable but without prejudice to other terms and conditions of the Contract.

Both parties shall keep a record of the circumstances referred to above which are responsible for causing delays in the execution of the services and shall give notice to the other party of any such cause as soon as it occurs. An event of Force Majeure, where so

ever it occurs, provided it affects either party in fulfilling its obligations under this contract, shall justify the affected party's claim of Force Majeure. Shall one or both the parties be prevented from fulfilling their contractual obligations by a state of Force Majeure lasting continuously for more than a month, the parties shall consult with each other regarding the future execution of the contract.

17.0. TAXES AND DUTIES

17.1 SERVICE TAX

Service tax, if applicable shall not be included but indicated separately in schedule of prices (percentage of service tax applicable & amount on which it is applicable.)

17.2 INCOME TAX

Income tax at the prevailing rate as applicable and if applicable from time to time shall be deducted from the supplier's bills as per Income Tax Act. and a certificate issued (TDS Certificate).

18 RISK COVERAGE

The Supplier shall arrange comprehensive risk coverage at his own cost covering the value of equipment including transportation to the site from parties work's, storage at site. The period of such coverage shall be up to contractual completion period or any extension granted by Department thereof.

19 SECURITY DEPOSIT

19.1 The supplier whose tender is accepted will be required to furnish by way of Security Deposit for the due fulfillment of the contract such a sum as will amount to 10 % of the contract price of the work awarded.

19.2 The security deposit (bearing no interest) shall be held by the Department as security till satisfactory competition, testing and handing over of all the system and for the due performance of all supplier's obligations under the contract as per delivery period or extension granted thereof by the Department.

19.3 The supplier within 10 days of Purchase Order or signing of Contract , deposit with the Accounts officer, Satish Dhawan Space Centre SHAR, Sriharikota as detailed above by any one or more of the following modes namely

(a) By a crossed demand draft in favour of Accounts officer, Satish Dhawan Space Centre SHAR drawn on SBI and payable at Sriharikota.

(b) By an acceptance bank guarantee. The bank guarantee shall be from a nationalised bank for & shall be valid for 30 days beyond completion period.

19.4 In case of breach of contract, the Security deposit shall stand forfeited in addition to other relief available to the Department under this contract.

18.0. CONFIDENTIALITY

- If the documents supplied by the Department are marked 'restricted use' the Supplier shall take all necessary steps to ensure that the requirements of the contract or any specification, plan, drawing, pattern, sample or information supplied by, or on behalf of, the Department in connection therewith shall not be disclosed to any person other than a person employed or engaged by the Supplier, whether under sub-contract or otherwise, for the performance of the contract.
- Tenderer shall guarantee that the information and data received from the Department shall be classified as confidential within the meaning of official secret act and will not be divulged to any third party without prior written permission from the Department. All drawings and documents shall be returned after completing the work.

19.0. WARRANTY

Tenderer shall warrant that the design and engineering services as specified in the Annexure-1 document to RFP shall be in accordance with sound and established engineering practices, using international standards and Indian codes and regulations, wherever applicable, for the purpose specified, free from defects and suitable for respective uses intended.

In case of fault engineering, i.e error (or) omission in the technical services performed by the tenderer or deviation in the performance of the system during commissioning, for which tenderer is solely responsible, tenderer shall provide services for corrective engineering with out any additional cost to Department, and no such liability shall lie even after expiry of the contract period.

20.0. ARBITRATION

In the event of any question, dispute or difference arising under these conditions of any condition in the purchase order or in connection with this contract, (except as to any matters the decision of which is specially provided for by these conditions) the same shall be

referred to the sole arbitration of the Head of the Purchase office or of some other person appointed by him. The arbitration shall be with in India and based on the rules governing arbitration with in India. The arbitrator may be a Retired Judge or a Government Servant or any other responsible person, that he had to deal with matter to which the contract is related or that in the course of his duties, he has expressed views on all or any of the matters in dispute or differences. The award of the Arbitrator shall be final and binding on the parties of this contract.

21.0. APPLICABLE LAW AND JURISDICTION

The laws of India shall govern this contract for the time being in force. The Courts of Andhra Pradesh, India only shall have jurisdiction to be with and decide any legal matters or disputes what so ever arising out of the contract.

22.0. FORCE MAJEURE

Shall a part or whole work covered under this agreement be delayed due to reasons of Force Majeure which shall include legal lockouts, strikes, riots, civil commotion, fire accident, quarantines, epidemic, acts of God and Government, fright embargoes, the completion period for work, equipment referred to in this agreement be extended by a period not in excess of the duration of such Force Majeure. The occurrence shall be notified by either party within reasonable time.

23.0. SUB CONTRACTING

The tenderer shall not subcontract the performance of all the works and services subject of this Contract. Also, the tenderer shall not subcontract part of the works and services without the written consent of the Department unless the contract stipulates otherwise.

Such consent shall not release the Tenderer from the liability and obligations imposed on it by this contract, and it shall remain responsible for any act, error or negligence made by any subcontracting consultant, its agents, employees or workers.

24.0. PRE-QUALIFICATION CRITRIA

Bidders shall meet the following evaluation criteria. Offer of the bidder which are not meeting the following criteria will not be considered for evaluation.

1. Bidder shall submit the questionnaire given in the section 25.0 of this document

2. Bidder shall have experience in extending technical services in terms of design, analysis, validation for
    a. Construction of high raise building of RCC and structural construction
    b. Electrical and MEP works
    c. Heavy mechanical equipments / structures involving mechanical, hydraulic, electrical and instrumentation systems.
3. Bidders shall have exclusive captive manpower resources of different categories namely Engineers, analysts, draftsmen etc sufficiently to carry out the tendered work in house with in the delivery schedule.
4. Bidder's turnover shall be at least 10 Cr. Per year.
5. Bidder shall have good infrastructure including office space, computers, software, printers / plotters and other resources for carrying the technical services in house.

25.0 QUESTIONNAIRE FOR VENDOR EVALUATION

1.0 DETAILED COMPANY PROFILE

2. 0 PRODUCT DETAILS

Name, size range, Models, Grades, standards etc,

Please attach product catalogues, leaflets, literatures etc.

3.0 INSPECTION AND TESTING FACILITIES

Third Party Inspection Agencies

4.0 DESIGN/DEVELOPMENT/DOCUMENTATION/ ENGG. FACILITIES

5.1 Nature of Services

5.2 Software

i. CAD platform:

ii. Design and Analysis platform:

iii. Other software:

iv. Mode of data transfer:

5.0 EXPERIENCE / SERVICE INFORMATION

6.1 List of important customers and list of contracts executed (order no. & date, delivery date etc -attach separate list for last two years).

S.No	Name of the project	Client	Location	Duration of the project	No. of workforce involved

List major projects on-hand

S.No	Name of the project	Client	Location	Duration of the project	No. of work force involved

6.0 TECHNICAL COLLABORATION

7.0 DEALER SHIPS AND FRANCHISEES

8.0 FINANCIAL PARAMTERS

Last three years financial parameters. (Please also attach your Income Tax Clearance Certificates and balance sheets)

9.0 RESOURCES

1. Floor Area/Open Area of works/office.
2. No. of Employees

   Sr. level Managers

   Administrative officers/qualifications

   Design Engineers

   Draftsmen

   Analysts / Verification Engineers

Annexure I

REQUEST FOR PROPOSAL

Brief description and detailed specifications of facilities/ systems covered under scope

November 2013

Satish Dhawan Space Centre SHAR

INDIAN SPACE RESEARCH ORGANISATION

Sriharikota 524 124

CONTENTS

1.0. SECOND VEHICLE ASSEMBLY BUILDING (SVAB)

Second Vehicle Assembly Building (SVAB) is mainly intended for receiving the segments / stages / sub-systems of the launch vehicle, tilting them inside the facility wherever required, integrating them on a Mobile Launch Pedestal (MLP), performing checkout operations (stage level & full scope) and rolling out the vehicle for launch from SLP. In case of a launch from TLP, the additional activities of attaching an Auxiliary Umbilical Tower (AUT) to MLP precedes the vehicle integration and is followed by operations like cryo arm, cryo hoses and umbilical connection between AUT & vehicle and full vehicle checkout, are also carried out in the SVAB itself. The facility is sized to carry out the integration of existing and some of the future launch vehicles of ISRO.

SVAB is a fully air-conditioned concrete structure of suitable dimensions, which provides a comfortable and controlled environment for integration of the launch vehicle. The facility is equipped with the following provisions to carryout vehicle assembly operations:

- Six sets of Swing Cum Vertically Repositionable Platforms (SCVRPs) in combination with six nos. of Folding Cum Vertically Repositionable Platforms (FCVRPs) to approach the vehicle and front face of AUT.
- Seven sets of mechanized Horizontally Sliding Doors (HSDs) on the front side to give way for the integrated launch vehicle to move out and one set of HSD on rear side to receive the vehicle sub-systems/ stages
- One no. of Nozzle Assembly Tower (NAT) and two nos. of Segment Assembly Towers (SATs) with foldable platforms at three levels for simultaneous assembly of two S200 motors.
- 400/60 t EOT crane for handling the vehicle stages/ hardware,
- Rail track with one set of ground anchors at identified location for positioning and anchoring the MLP
- Two nos. of elevators for goods cum passenger travel

Further, SVAB need to have interfaces for the following sub-systems which become part of the facility.

- Air conditioning and Satellite cool air systems
- Checkout cables and terminations
- Helium, Nitrogen and compressed air supply systems
- Electrical power supply, distribution and aviation lamps
- Earthing and Lightning Protection System
- CCTV and communication network

The general arrangement of SVAB is shown in **Fig 1 & 2**

1.1 CIVIL STRUCTURE

1.1.1 Purpose

To serve as weather proof shelter for vehicle assembly enclosed by doors on the exterior and acting as an interface inside for handling and approach systems

1.1.2 Description

SVAB is basically a RCC framed structure of clear internal width 34.0 m, length 70.0 m and height (at spring level) as 96.0 m. It is provided with necessary embedment for supporting EOT crane, fixed platforms/catwalks and guide columns for platforms. Whole building being the load bearing framed RCC structure, all sides are closed with RCC walls other than the door opening area. Cat walks are provided along the portals on both sides at all floor levels connected on the rear side above 20.0 m. Embedments are provided for fixing doors and their mechanisms and also for the requirements of elevator. Stair cases are provided for access to various levels. Rails are laid in flush with floor for MLP movement from one side of SVAB. Anchors are provided on floor on either side of the track for anchoring the MLP during vehicle integration.

1.1.3 Functional Requirement/ Specifications

- It shall be weather proof and air-conditioned enclosure for Launch vehicle during integration and checkout activities.
- It shall accommodate MLP, over which the vehicle will be assembled and three structural towers for S200 motor integration.
- It shall provide interfaces for Repositionable Platforms & Horizontal Sliding Doors (HSDs) and their drive mechanisms.
- Ground flooring shall be designed to carry the loads of trailers with sub-system loads, MLP hauler loads, etc.
- Foundations shall be provided for MLP rail track suitable for 125 t wheel load and for four ground anchors to support 600 t load each.
- Ground anchors shall take care of repositioning accuracy of ±15 mm laterally and ± 5 mm longitudinally
- Two nos. of 20 t capacity hooks shall be provided from the roof for supporting the chain pulley block / winch pulley for crane erection and maintenance works.
- The building shall be provided with lifts, staircase and cat walks to reach various floor levels.

- The building shall have provisions to house AHUs, AC ducts, satellite cooling ducts, pipelines for Helium, Nitrogen & Compressed air service, trenches/ ducts for power, checkout & communication cables.
- The space available in between portal frames is used for accommodating lifts, stair cases, A/C plant equipment, satellite cooling system, air handling units, drive mechanisms and diversion pulleys of platforms & doors, duct for service gas lines, checkout, power & control cables and to position integration platforms & equipments.
- For the elevators, embedments shall be provided at all floor levels to support lift guide rails and for lift machine equipment inside machine room.
- 1.6 m deep pits shall be provided for both the lifts below 0.0 m level. No water should seep into the pits. Bottom of the pit shall be provided with embedments for supporting the lift end buffers.
- The embedments/provisions are required to be provided for cat walks, platforms & drive mechanisms, Nozzle and Segment Assembly Towers, doors & drive mechanisms, cranes, elevator , A/C, Air Handling Units, satellite cooling system, ducts for service pipe lines, Checkout and power cable trays, light fittings, lightning arrester masts, maintenance cradle etc.
- Embedments shall be provided on portal frames to support four guide columns, two on either side of vehicle. These guide columns shall be connected with the embedments of the structure at all floor levels starting from 13.0 m level to 70.0 m level. Guide columns form part of platforms whereas the embedments to reach up to guide columns form part of the building structure.
- Embedments shall also be provided inside portal frames on the floor for supporting hoisting drive mechanisms and diversion pulleys of hoisting motion of platforms.
- Hand rails shall be provided on all catwalks and around all floor cut outs and on roof top for personnel safety. Hand rails shall be of two tier construction with a toe guard of 100 mm. The hand rail height shall be 1.0 m nominal.
- At the location of entry to platforms from catwalks, manually operated sliding hand rails with locking provision shall be provided to the extent of 1.5 m on either side of vehicle centre line.
- The building shall be provided with necessary openable type glass windows for getting natural light as well as for ventilation purpose.

Window panels shall be capable of withstanding cyclonic wind and they should be leak proof to prevent entry of rain water.

- Outside stair cases shall be planned for approaching A/C plant rooms.
- Provisions shall be made for the building to install multiple escape chutes.
- Embedments shall be provided for supporting Horizontal Sliding Doors (HSDs) on the outside of the building structure and for door drive mechanisms including diversion pulleys in the portal area. The loads shall be obtained from door drive mechanism design.
- Front and rear walls of the building shall have smooth surface in the areas of door movement to have water proof sliding joint between walls and doors when the doors are closed.
- There shall be no trough or any projections from the building for water collection. No water shall get collected on roof of building. There shall be suitable drainage arrangement for the disposal of rain water from the roof. No water shall enter on to the floor of the SVAB, when the doors are closed.
- Hoods shall be provided over horizontal sliding doors so as to prevent entry of water between door & wall and other interfaces even during cyclone.
- Embedments shall be required for the LT girder of 400/60 t crane (crane LT rail top is 82.0m). Span of the crane (distance from rail to rail) to be fixed optimally based on crane design to meet the approach requirements and building design.
- Provision of toilet and drinking water (with a cooler) shall be made to meet the requirements of atleast 25 persons at six locations (3 on either side) equidistant over the height between ground level and 46 m with proper drainage for waste water.
- On western and southern sides of the building, a balcony of size 3 m x 1.5 m shall be provided with a floor loading of 200 kg/m^2.
- MLP track and anchor foundations inside the building shall be provided as part of building ground floor.
- Floor cut-outs shall be provided through out the height for two lift wells and for cables and gas lines routing
- Loads to be considered for civil structural design shall be:
    - Cyclonic wind loads corresponding to 180 kmph (3 sec gust) at 10 m height (as per IS : 875 latest revisions and enhanced by a factor of 1.3 as per IS 15498) with K1 : 1.09 (25 years life span, 5% risk level), K2 : For category -1 & class - C structures and K3 : 1.0

- Seismic loads for zone III as per IS : 1893
- Live loads due to personnel & equipment
- Loads due to crane of 400 t capacity (self weight + pay load weight of 400 t + dynamic loads due to crane starting and stopping with loads acting at 82.0 m level) and loads due to 20 t capacity hook provided in the roof of SVAB for crane erection and maintenance.
- Axial, lateral, vertical loads and moments of the platforms (dead weight+ live load of 200 kg/m^2 UDL & 1500 kg tip load+ folding drive mechanism weight and the dead weight of the platform) shall be considered for the design.
- Loads due to the doors and associated drive mechanisms (dead weight+ wind loads)
- Live load on catwalks and floors except ground floor is 200 kg/m^2.
- Loads due to FCVRP hoisting drive mechanism, door mechanism and associated systems, AC equipment, elevators and electrical equipment shall be considered for the design of the floors

- Floor load on ground floor shall be as per CLASS-AA and also considering the load due to MLP hauler
- Wheel load of 125 t on twin rail track with centre to centre distance of 14 m and with distance between twin rails as 750 mm shall be considered.
- On the roof a live load of 150 kg/m^2, loads due to masts of the lightning protection system, maintenance cradle and two nos. of 20t capacity hooks shall be considered.

1.1.4 Proposed Configuration

The proposed configuration of the building structure with the given below features is shown in **Fig. 3, 4 & 5**

- The building is a framed structure with concrete walls and catwalks.
- The tentative external dimensions of the building are of 70.0 m length, 50.0 m width, and height up to spring level from rail top being 96.0 m.
- 400 t crane rail top level: 82.0 m and span 35.5 m
- Number of floors: 22 with floor levels: 0.0 m, 4.5 m, 9.0 m, 13.0 m, 17.0 m, 20.0 m, 24.0 m, 27.0 m, 31.0 m, 35.0 m, 38.0 m, 42.0 m, 47.0 m, 51.0 m, 55.0m, 59.0 m, 63.0m, 67.0 m, 70.0m, 74.0 m, 78.0 and 82.0 m
- The wall on front face is extended on either side to support Horizontal Sliding Doors.
- The width of the portal is 8.0 m
- The width of the side walls above crane LT rail is reduced to accommodate crane girders.

1.2 PLATFORMS

1.2.1 Purpose

To provide access to the launch vehicle and to the front face of Auxiliary Umbilical Tower (AUT) at required levels between 13.0 m and 70.0 m elevation.

1.2.2 Description

For carrying out the vehicle integration operations, personnel are required to reach the vehicle at various levels in SVAB throughout its height and approaches are required close to the vehicle. Though most of the operations are carried out sequentially, there are certain activities that require simultaneous approach at two or more levels. To meet these simultaneous operational requirements, 6 nos. of repositionable platforms are envisaged. These six platforms shall serve all the operational platform levels from 13 to 70 m level. One platform consists of one set of Swing Cum Vertically Repositionable Platforms (SCVRP) and one number of Folding Cum Vertically Repositionable Platform (FCVRP).

For repositioning purpose, these platforms are guided by two guide columns on either side. These platforms are also required to be folded or swung out for allowing crane hook to reach bottom levels or for moving the launch vehicle out of SVAB. Electro mechanical/ electro hydraulic systems are planned to be used for folding, swinging and repositioning operations. The FCVRPs consist of two portions out of which one is foldable and the other is fixed. The foldable portion is again made up of a permanently hinged part and a replaceable part having cutouts suitable for different vehicle configurations. Both the fixed and foldable parts move up and down whenever FCVRP hoisting drive is operated. The SCVRP also has replaceable parts to suit the vehicle profile.

1.2.3 Functional Requirements/ Specifications

- From the centre of launch vehicle, a clear space of 6.0 m shall be provided on east side (FCVRP side) and 15.0 m on west side (SCVRP side), when platforms are in folded/ swing-out condition, for the EOT crane hook approach to lower levels, so as to enable movement of MLP with vehicle and AUT out of SVAB.
- Platforms shall be configured to have minimum 2 m working space all around the vehicle.
- Platforms shall be configured with permanent framework and detachable portions to convert the platforms for various vehicle configurations. The present scope of work covers permanent frame work with independent detachable parts of GSLV Mk II and LVM3.
- Platforms shall have cut-outs suitable to external configuration of launch vehicle with a possibility to cover/ close the cut-outs meant for strap-ons or core stage depending on the integration requirements.

- The platform projections between strap-ons shall be slideable into the platform before folding operation to avoid interference with the vehicle.
- Provision shall be made for bringing any two adjacent platforms to closest position with not more than 4.0 m level difference.
- Under actual operating loads, the platforms shall be sturdy and shall move up and down smoothly.
- It shall be possible to carry out all the platform operations (both hoisting and folding) from the fixed portion.
- Some interconnecting locking arrangement shall be provided at the interface of the two SCVRPs and FCVRP on the opposite side so that load transfer is possible between them and tip deflection and dip is within allowable limits.
- The platform may be configured with increased sizes at a later date for future launch vehicles. To facilitate this, the building structure, guide frame, hinge support structure and associated drive mechanism shall be designed with 50% margin taking into account the future platform weight.
- Possibility should exist to incorporate clean room of one lakh class between desired levels using antistatic winding curtains. In view of this the mechanism for hoisting and folding/swinging should not interfere with the clean room provisions.
- There should be possibility to include a dedicated crane of low capacity for clean room operations.
- The platforms are to be designed for live load of 200 kg/m^2 or tip load of 1500 kg as UDL at the edge of platform+ 4 t equipment load distributed at four points spaced at a distance of 1.0 m in addition to dead loads computed based on the unit weight of materials as per IS : 875 Part 1. These loads shall be considered for design of other sub-systems also.
- Tip deflection of the platform shall be limited to L/325 mm where L is the cantilever length of the platform. If the deflection is found to be excessive, suitable upward camber may be thought of to compensate the deflection due to self weight.
- No oil shall drip from the gear box or any part of the system. However suitable oil drip tray shall be provided for both hoisting and folding mechanisms.
- Effective toe guards shall be provided for all the platforms and guards shall be provided for all rotating parts.
- Foldable hand rails shall be provided on the foldable platforms. Hand rails shall not interfere with the vehicle or guide column or guide frame, when the platform is folded. Hand rails shall be provided around fixed platform with required openings for entry from catwalks. All entry openings shall be provided with sliding hand rails.

- All electrical systems like motor, thrustor brakes, over load sensing system, limit switches, starters, etc. are all of flame proof type suitable for Class-IIB application.
- The folding and hoisting drive shall be operable manually in case of failure of electrical power.
- The gear-boxes used shall be non-reversible type both for folding and hoisting to prevent the possibility of the platform lowering by its own weight.
- Flame proof push button switch shall be provided for operation near the mechanism.
- The drive motors shall be suitable for duty class S4, cyclic duration factor 40% and number of starts/hour 10.
- The permanent framework and the detachable portions of the platforms are to be configured with sliding/ folding/ rotating parts whenever required to facilitate platform folding/ swinging without interference with vehicle parts.
- In case or SCVRPs, the permanent framework at pivot junction shall have openings (without vertical bracings) to enter the working zone of the platform.
- The platforms shall be designed to operate both the halves independently.
- Suitable locking arrangement shall be provided for the platform in retracted position.
- The drive system for platform swing and repositioning operations shall be designed with the following requirements:
    - The speed of folding/ swinging operation shall be 24 deg/ min and 1 m/ min for vertical repositioning.
    - The mechanism for swinging may employ bearings of suitable capacity. The design shall take into account lubrication and maintenance features.
    - The hoisting mechanism shall be designed to move the dead weight of the platform with swinging drive system and the live load. A factor of safety of 5 on breaking load for one rope failure case shall be considered.
    - Maximum size of wire rope employed shall be of 26 mm and if more loads are encountered multiple sheave pulley blocks shall be employed
- Operation control for all the platforms shall be by means of local control panels located on the platform

1.2.4 Proposed Configuration

The basic configuration of one set of platforms (two SCVRPs + one FCVRP) for GSLV Mk II and LVM3 configurations is shown in **Fig 6 & 7.** The construction/ design features of the platforms are given below:

- Six sets of Platforms shall be provided so as to provide approach throughout the vehicle height between 13.0 m to 70.0 m levels as given below:

Platform	Working levels
Platform1	13.0 m to 20.0 m
Platform 2	20.0 m to 27.0 m
Platform 3	27.0 m to 35.0 m
Platform 4	35.0 m to 47.0 m
Platform 5	47.0 m to 59.0 m
Platform 6	59.0 m to 70.0 m

- The platform cut-outs are made replaceable to suit different launch vehicle configurations considered in SVAB. However, all other elements of platforms such as hinges, pivots, drive systems, pulley systems, carriages, etc. (except replaceable platform portion) shall be common for all platform configurations to suit any launch vehicle.
- Each half of FCVRP consists of a foldable platform, a fixed platform, guide frame, folding drive mechanism, hoist drive mechanism, ropes, guide pulleys, local control panel, over-load sensing devices, limit switches, trailing cables, safety ropes, rail clamps, mechanical locking devices, etc.
- Under folded/ swing-out condition, the platform is provided with a mechanical positive locking device.

GUIDE COLUMNS

- Guide columns are common for all the platforms. Both the guide columns on either side are fixed to the horizontal embedment beams provided from building structure. The guide columns have no connection to the ground.
- Guide columns are made-up of suitable sections. In between two guide columns, the guide frame/ carriage structure moves up and down.
- To the guide frame, folding portion of the platform is hinged on one side. On the other side, fixed portion is provided. The folding portion of the platform is operated with the help of folding drive system located on fixed platform and using direction changing pulleys.

GUIDE FRAMES/ CARRIAGES

- The guide frames/ carriages are designed to move within guide columns freely without any interference with fixed structural members. They should support the platform, folding/ swing drive mechanism with all accessories like pulleys, shafts, actuators, bearings, tie ropes, folding ropes, spring stops, limit switches, local control panels, etc.
- The hoisting drive lifts/lowers the guide frame (in case of FCVRP) and pivot (in case of SCVRP) up or down and the guide frame is guided using 2 nos. of guide columns provided vertically from 10.0 to 73.0 m level.

FOLDING DRIVE MECHANISM

- 6 nos. of folding flame proof drive mechanisms with associated sub systems such as direction changing pulleys, hinges, mechanical locks, spring thrusters, tie ropes, folding ropes, folding rope fixed end brackets, load sensors, flame proof junction boxes, cables, flame proof local control panels, flame proof limit switches and all other accessories required for the folding platform to perform the intended operation.
- The folding operation is carried out by the electrically operated winch type folding drive mechanism. The motor shaft transmits power to a rope drum through a non reversible worm gear box. In turn, the rope drum pulls up or releases down the free end of foldable platform by winding or unwinding the two ropes thereby folding or unfolding the platform about the hinges. Electrohydraulically operated flame proof thruster brake mounted on input shaft of worm-reducer is used for braking the operation. The drive gear box shall be of non-reversible type.
- Controls for both hoisting and folding mechanisms shall be provided in a single local control panel. Local control panel of each half of the FCVRP is mounted on respective fixed platform. The platform will be operated electrically from control panel. The folding / hoisting operations are carried out manually by operating the input shaft of the drive system.
- To ensure that the platforms are not folded beyond 90°, suitable spring stops shall be provided on the structure. Such spring stops shall also help to generate requisite initial thrust during unfolding of the platform. Tie ropes are provided at both ends of the platforms to take the live loads coming on the platforms in the fully unfolded condition for safety purpose.
- The fixed ends of folding and hoisting platforms have provision for adjusting tightness of ropes so as to equalise the loads on both ropes.
- As an additional safety measure for hoisting mechanism, each of the two ropes shall be designed to withstand dead weight of the connected platform

and associated drive machinery in case of accidental failure of one of the ropes.

- For vertically repositionable platforms, the two ropes used for hoisting have to wind and unwind by the same length in course of its travel between lowermost and uppermost position.
- Load sensing devices (Load cells) are positioned below the drive system pulleys with amplifiers and digital load display systems positioned near the local control panel. The system is adjusted such that in the event of load exceeding 125% of the normal load the drive system shall trip automatically. The system is of flame proof type and 2 nos. are provided for each of the hoisting and folding drive systems.

SWING DRIVE MECHANISM

- 12 nos. of swing flame proof drive mechanisms with associated sub systems such as rotary actuators, mechanical locks, shafts, tie ropes, bearings, load sensors, flame proof junction boxes, cables, flame proof local control panels, flame proof limit switches and all other accessories are required for the swing platform to perform the intended operation.
- The swing operation is carried out by the electro hydraulically operated drive mechanism.
- For the swing drive, there is a carriage that carries the Pivot. A splined shaft runs through it and mates with the rack on the actuator, when signal is given to the hydraulic actuator, the rack move and thus imparts rotary motion on the vehicle.
- Mechanisms for swing drive to be provided on carriage of the platform.
- Controls for both hoisting and swing mechanisms shall be provided in a single local control panel. Local control panel of each half of the SCVRP is mounted on respective fixed platform. The platform will be operated electrically from control panel. The swing / hoisting operations shall be carried out manually by operating the input shaft of the drive system.
- To ensure that the platforms are not swung beyond 90°, suitable spring stops shall be provided on the structure. Such spring stops shall also help to generate requisite initial thrust during swing-in of the platform.
- As an additional safety measure for hoisting mechanism, each of the two ropes shall be designed to withstand dead weight of the platform and associated drive machinery in case of accidental failure of one of the ropes.
- For vertically repositionable platforms, the two ropes used for hoisting shall wind and unwind by the same length in course of its travel between lowermost and uppermost position. The maximum acceptable level difference

between edges of guide frame shall be 5 mm. The diameter tolerance of rope drum and other components shall be controlled to achieve this.

- Load sensing devices (Load cells) are positioned below the drive system pulleys with amplifiers and digital load display systems are positioned near the local control panel. The system is adjusted such that in the event of load exceeding 125% of the normal load the drive system shall trip automatically. The system is of flame proof type and 2 nos. are provided for each of the hoisting and folding drive systems.

HOISTING DRIVE MECHANISM

- 18 nos. of flame proof hoisting drive mechanisms, with associated sub system such as direction changing pulleys, main wheels, side thrust wheels, hoisting ropes, fixed end brackets for ropes, rail clamps, mechanical locks, load sensors, flame proof junction boxes, cables, flame proof local control panels, flame proof limit switches and all other accessories required for intended satisfactory and safe hoisting operation.
- The hoisting operation of the folding platform will be done by electrically operated winch mechanism. The motor shaft transmits power to a rope drum through a non reversible worm gear box. In turn, the rope drum pulls up or releases down the guide frame by winding or unwinding the two ropes. The guide frame carries the platform up and down by moving along the vertical guide way column on four wheels provided on it.
- Electrohydraulically operated flame proof thruster brake which is normally in closed condition under spring force, mounted at the input side of the worm-reducer is used for braking the hoisting motion. However the drive gear boxes shall be non reversible type. Hoisting drive mechanisms are placed in portal frames of the building.

GENERAL

- From catwalks, approach provisions are made to reach the platforms.
- The vertical mismatch at any point between the two halves of the platform at a level not to exceed 5 mm in unfolded position without any live load.
- The deflection at the tip of the platform in the fully unfolded condition under full load shall not exceed 10 mm
- Flame proof limit switches are to be incorporated for folding, swinging and hoisting operations. For hoisting motion anti-collision limit switches shall be provided for all platforms both for up and down motions.
- Various machine elements such as ropes, sheaves, rope drums, gear boxes, brakes, shafts and axles, couplings, wheels and spring stops shall conform to the requirements of IS : 3177 and CMAA specification no. 70 as applicable. For the purpose of service classification, the mechanism under consideration shall be treated as equivalent to mechanism class 2 of IS: 807.

1.3 S200 Towers

1.3.1 Purpose

One number of Nozzle Assembly Tower (NAT) is envisaged to assemble the S200 nozzle to the Nozzle End Segment (NES) by properly aligning the two components. Two nos. of Segment Assembly Towers (SATs) are required to perform the Flex Nozzle Control (FNC) Actuation trials by mating nozzle and actuators with Short Motor Case (SMC) in pressurized condition, to mate the NES and nozzle with the Strap-on Base Shroud (SBS) and to carry out the joint integration- Mid Segment (MS) with Nozzle End Segment and Head End Segment (HES) with the Mid Segment for flight motor preparation. Final assembly operations on the S200 motor, like Thermal Boot assembly, Jettisoning Motor assembly etc. before placing on the Mobile Launch Pedestal are also carried out in SAT.

1.3.2 Description

For carrying out the S200 assembly operations, dedicated towers are planned to facilitate the preparatory operations and functional tests. Two Segment Assembly Towers are provided to facilitate simultaneous assembly of two S200 motors. Personnel are required to reach the motor at various levels in SVAB at the segment joint locations and approaches are required close to the motor. To meet these operational requirements, three nos. of platforms are planned. Electro mechanical systems are planned to be used for folding operations if the platforms need to be folded. The towers with 'U' shaped opening towards the bay area extend from ground to a particular height and provide support for the platforms. There are two fixtures viz. Nozzle Assembly Fixture in the NAT and Full Motor Assembly Fixture (FMAF) in SAT. These fixtures support the respective launch vehicle assemblies/ sub assemblies.

1.3.3 Functional Requirement/ Specifications

- The towers shall be made of structural steel framework and connected to the building main structure (floor and columns) through embedments.
- The foundation of the SVAB ground floor and the vertical columns shall also take into consideration the load transfer due to these three towers and the associated fixtures.
- The cutouts of the platforms will conform to the dimensions of the S200 motor, that is, 3200 mm diameter with 150 mm clearance all around. However possibility should exist to alter the cutout sizes and other interfaces to use the towers in future for any other diameter of the stages.
- The platforms provided for approach shall be foldable type to avoid interference with the flight systems and handling equipment.

- Wherever possible, the folding shall be mechanized and the mechanisms shall be located in such a way that they do not cause any hindrance to the movement of personnel for working on the platform.
- The loading details of the foldable platforms in these towers shall take into consideration the criteria outlined elsewhere in the document for the configuration and design of FCVRPs wherever applicable.
- The tower shall be designed for self weight of the tower + Platforms for self weight+ live load of 200 kg/m^2 + Tip load of 1500 kg as UDL at the edge of platform (Dead loads computed based on the unit weight of materials as per IS : 875 Part 1).
- The Nozzle Assembly Fixture comprises of Nozzle support fixture designed for a capacity of 7.5 t allowing a deflection of 1.6 mm and the Nozzle End Segment Support fixture designed for a capacity of 140 t allowing for a maximum deflection of 2 mm. The Nozzle Support Fixture should have a repositioning capability in XZ plane and rotational capability about Y axis for ±5 pitch.
- The full motor assembly fixture is designed for a load of 300 t allowing for a maximum deflection of 3 mm.

1.3.4 Proposed Configuration

Nozzle Assembly Tower and Fixture

- The nozzle assembly tower is of 8 x 8 m in size and the height of 10.5 m. It is made up structural steel deriving support from the SVAB floor and the vertical columns in the region.
- It is provided with a structural platform at 10.47m elevation. The sliding/folding segment of platform shall have a clear opening of 3.5 m to allow the Nozzle End Segment of 3.2 m diameter to move inside the tower.
- A fixture in the shape of pedestal resting on six columns and radial beams is provided to support the Nozzle End Segment which rests on a machined ring.
- While configuring the structure, interface to be generated for ovality correction ring retraction mechanism.
- To access the flange level, sectored platforms are provided in six parts and these can be folded with a ratchet mechanism
- A fixed ladder is to be provided reach the platform location from the bay area directly.
- To support the nozzle, a machined ring is provided, which in turn is supported on hydraulic jacks.
- The minimum movement by a jack shall be 0.1 mm

- Linear movement of the slides ± 25 mm

Segment Assembly Tower and Fixture

- The Segment Assembly Tower is a built up structure of steel members of size 8 m x 8 m and 25.5 m height with fixed platforms at 2.7m, 9.0 m, 21.32m and 23.84 m elevation.
- The spacing of members in the tower is such that the nozzle of S200 (Ø3139mm) should have interference free movement inside the mating segment placed on the Full motor assembly fixture.
- Interfaces to be provided for FNC tank mounting brackets on SAT columns facing bay area.
- Interfaces to be provided at 2.7 m elevation to mount actuator handling winch mechanism.

The configuration of S200 towers is depicted in **Fig 8**

1.4 Doors

1.4.1 Purpose

To close the openings on SVAB front and rear sides in such a way that launch vehicle is protected from the inclement weather conditions from outside and a controlled environment is maintained inside.

1.4.2 Description

For carrying out the integration activities in SVAB, the sub-systems are brought inside through the doors on one side. On the other side also doors are provided enabling the movement of the integrated launch vehicle along with MLP and AUT to the launch pad. The configuration and design of the doors shall be such that even in case of cyclone, water or wind gust should not enter the building.

1.4.3 Functional Requirement

- Doors shall provide clear opening for the movement of fully integrated launch vehicle and AUT on MLP from the front side which is facing towards east. On the rear side, clear opening shall be provided for the movement of the sub-systems on trailers.
- Doors shall withstand cyclonic winds and the mechanism shall be operable at 18 m/s wind velocity.
- Doors in closed condition need to protect the sub-systems and integrated launch vehicle in SVAB from cyclonic winds and rain.
- Doors shall have perfect sealing at intra door interfaces as well as interface with the building walls to prevent leakage of rain water into SVAB even during cyclone. In between adjacent doors, tongue and groove interface may be considered.
- The operation of each door shall be independent without any constraint.
- The Horizontally Sliding Doors shall be designed for the following load conditions:
    - Self-weight, wind loads and acceleration loads.
    - Vertical loads: Dead load have to be computed based on the unit weight of materials as per IS: 875 Part 1. Dead weight of door structure shall be considered for the design of the associated sub-systems.
    - Cyclonic wind loads corresponding to 180 kmph (3 sec gust) at 10 m height (as per IS : 875 latest revisions and enhanced by a factor of 1.3 as per IS 15498) with K1 : 1.09 (25 years life span, 5% risk level), K2 : For category -1 & class - C structures and K3 : 1.0

- Operating wind loads at wind velocity of 18 m/s for the drive system
- Wind load for door in open condition : 18 m/s
- Acceleration and deceleration loads at the rate of 0.03 m/s^2
- The following load combinations may be considered for designing of door structure:

  Case I: Dead load + Cyclonic wind load

  Case II: Dead load + operational wind load + inertial loads

CLEAR OPENING

Number of doors required is to be decided to meet the clear opening requirements as given below:

Location	Clear opening (m) at centre	Bottom level (m)	Top level (m)
On Front side	27.5 20.5 18.5 9.0	0.0 24.0 36.0 60.0	24.0 36.0 60.0 82.0
On rear side	15.0	0.0	20.0

- Speed of operation of doors: 2 m/min
- The drive motor shall be suitable for duty class S4, cyclic duration factor 40% and number of starts/hour 10.
- Caving in of the doors shall be designed so that overall deflection of the SVAB structure shall not affect the operation of doors
- In closed condition, the matching edge of the two halves of each door shall be within the following tolerances:
- Lateral mismatch in the direction along the track : 10 mm
- Vertical mismatch : 10 mm
- Parallelism between two edges : 10 mm

DOOR LEAVES REQUIREMENT

- Door leaf design shall minimize the tractive effort required under operational wind loads.
- Each door leaf shall be fully cladded with GI plain/ corrugated sheets for withstanding cyclonic winds as per IS : 875

- Each door leaf shall overlap with adjacent door leaf as well as building structure appropriately and shall provide water leak dynamic joint. These joints are also to be maintenance free. The sealing arrangement to be provided for each leaf shall ensure a waterproof joint even during cyclone, when all doors are closed.
- Relief provided in the far end cladding to clear end stops on rails shall also be covered appropriately to prevent entry of water and birds.
- Maintenance free phenotherm insulation panels of suitable thickness shall be fixed inside the door leaves to maintain SVAB inside temperature at 30˚C.

CYCLONE LOCKS

- Additional cyclone locks shall be provided if required, to lock the doors with building structure. Cyclone locks shall be easily approachable from inside for locking and unlocking and necessary approach platforms are to be provided if required.

DRIVE MECHANISM

- The drive system shall be electrically operated enabling the opening and closing of the doors to desired limits.
- Overload protection shall be provided in the system by means of a hydraulic coupling in the drive system.
- Though specific codes and standards on design of this particular item are not available, the codes and standards followed for the design of EOT cranes shall be followed.
- For the purpose of service classification, the mechanism under consideration shall be treated as equivalent to mechanism Class 2 of IS 807

ELECTRICAL

- The selected HP rating of motors shall have a margin of 30% over calculated HP requirement to take care of deviations of calculated dead weight, etc.
- One Local Control Panel (LCP) for control of each half of the door shall be provided complete with all components and auxiliary contacts required and wire them.

SAFETY REQUIREMENTS

- The drive system for horizontally sliding doors shall be provided with travel limit switches of flame proof type. The enclosure shall be of IP: 55 type.
- For all the sub-systems of the door, suitable approaches need to be provided both for operation and maintenance.

- Effective guards shall be provided for all the rotating parts. All electrical equipment should be properly guarded for protection against accidental contact.
- All electrical items shall be of flame proof construction.

1.4.4 Proposed configuration

It is proposed to provide with eight pairs of Horizontal Sliding Doors (HSDs), seven on the front side between EL 0.0 and EL 82.0 and one pair on the rear side between EL 0.0 and EL 20.0. The size of doors and number of pairs of doors against the clear opening required for the movement of launch vehicle and AUT on MLP are given below:

Details of door size and required clear opening sizes					
Location	Door	Clear opening (m)	Width (m)	Height (m)	Total height (m)
On front side	HSD-1	27.5	27.0	13.0	13.0
	HSD-2	22.7	20.5	11.0	24.0
	HSD-3	20.5	20.5	12.0	36.0
	HSD-4	18.5	20.5	12.0	48.0
	HSD-5	18.5	20.5	12.0	60.0
	HSD-6	9.0	12.0	11.0	71.0
	HSD-7	9.0	12.0	11.0	82.0
On rear side	HSD-1	15.0	15.0	20.0	20.0

The general arrangement of doors is shown in **Fig. 9**

- The door drive mechanisms and the local control panels are placed on floors between portal frames for easy approach and maintenance. The ropes are taken through guide pulleys from door ends to the rope drum and wound on it thereby establishing link between the door and drive mechanism.
- To prevent the movement of doors in lateral direction and to support brackets with horizontal guide wheel assemblies are provided from building floor beams at appropriate levels as shown in general arrangement drawing.
- The doors are operated electrically from local control panel located near the respective drive system. Door operation shall be carried out manually also by operating the input shaft of the drive system with a suitable handle.

1.5 Maintenance Cradle

1.5.1 Function

Maintenance cradle shall be provided on the top of the SVAB to approach all sides up to the bottom. The cradle shall have 1.0 x 3.0 m size with a load carrying capacity of 300 kg. It shall be driven by motors for hoisting. Control shall be provided from inside the cradle. The motors used shall be weather proof and it shall have parking/anchoring provision at an approachable elevation.

1.5.2 Description

A maintenance cradle which moves all around on a mono rail mounted on top of SVAB structure is planned to access the external surfaces of SVAB

1.5.3 Specifications

A standard reputed make maintenance cradle with the following specifications shall be procured and installed on SVAB

Size	:1.0 x 3.0 m
Capacity	: 300 kg
Power supply:	: through festoon/hanging cable connected at the bottom of SVAB
Centre of monorail from the face of SVAB	: suitably located so as to have approach to the surfaces of SVAB and doors from the cradle
Material of construction	: Aluminium
Operation	: By push button system mounted on the cradle

2.0. SVAB AIR CONDITIONING & SATELLITE COOLING SYSTEMS

2.1 *SVAB Air Conditioning System*

The Air-conditioning system will be provided for integration activities and human comfort to maintain indoor temperature of 25±2°C and relative humidity of 65±5% in all the platform/floors from ground level to indoor ceiling level. The integration of vehicle will be done in an air-conditioned environment.

Functional Requirements/ Specifications

The Central chilled water AC plant shall be located adjacent to SVAB with the following features:

- The bay cooling shall be designed for recirculation type with minimum one air change.
- The Central chilled water AC plant shall comprise of water cooled/air-cooled screw/reciprocating type unit.
- The Chilled water plant shall have minimum 50% standby.
- The Chilled water pipe lines will be routed inside the SVAB where AHUs will be positioned. There shall be minimum 25% standby for AHU.
- AHU shall be Double skin With DIDW Centrifugal fan. Duct silencer/sound attenuation shall be provided at out let of AHU to reduce sound.
- Refrigerate -22 shall be used for air – conditioning systems.
- Reverse return piping shall be considered for designing the chilled water piping inside SVAB.
- The provision for heating of supply air in monsoon season to avoid condensation shall be considered while designing the system. Duct inside SVAB shall be insulated and covered with aluminum cladding to avoid condensation.
- A/C ducting construction shall conform to IS: 655-2006.
- Refrigerant pipeline shall be of MS black, heavy class and as per IS: 1239, Part-I, 2004.Pipe fitting up to 150mm dia. shall conform to IS: 1239, Part-II: 2011.
- Cast iron butterfly type manual valve shall be provided at water pipe line for isolation and flow adjustment.
- All outdoor units shall be designed to withstand 250 kg/m² wind pressure and earth quake. (Factor zone – III as per IS- 1893)

- Motors rating shall be 10 to 20% above the BKW de-rated for the ambient condition of 45°C.
- Chiller shall be horizontal shell and tube type construction with water to flow in the shell and the refrigerant inside the tube.
- Chilled brine pipeline up to sizes 150 mm dia shall be MS, E.R.W black, heavy class and as per IS: 1239, Part-I: 2004.
- Chilled water pipe line shall be cold insulated with phenolic foam / PUF / Isoloyd. The insulation material shall be in two halves of annual cylindrical shape to match the pipe size.
- Horizontal centrifugal pump with back pull out design shall be provided. Pump shall be coupled with motor by spacer type coupling and shall conform to the latest edition of the relevant standard.
- Pump shall be fitted with mechanical seal instead of gland to avoid any leakage. Pump casing, cover and impeller shall be of cast iron construction.
- The pump shall be heavy duty suitable for continuous duty and shall be standard product of the manufacture proven for satisfactory & reliable performance.
- AC plant along with AHUs shall be interfaced for remote operation, monitoring and control from AC plant.
- All the equipment shall be fully compatible with each other and capable of operating as a fully integrated system to deliver the specified output under design conditions
- The contractor shall be responsible for design of all material, equipment and services which are not specifically mentioned but are required for completeness of the system, safe operation and to meet the functional requirement
- The AHUs inside SVAB shall be interfaced with Fire Detection and Alarm system to trip the AHUs on receipt of signal and same time audio and visual indication shall be available for operational personnel**.**

2.2 Satellite and Vehicle Cooling System

Satellite cooling system is required to supply cool air to assembled vehicle for cooling the various electronic package i.e core base shroud, nose cone cooling,GS2 tank cooling, 1/2M, 2/3L ,EB. and space craft. The air will be cooled, dehumidified, filtered and supplied through aluminum duct to various ports. The cool air port will be interfaced to vehicle through AUT for launches from TLP.

Cooling system is planned to maintain required temperature and relative humidity inside the heat shield. The supplied air shall have 10, 000 class cleanliness. The

cool air will be tapped from the main duct to supply to vehicle and satellite subsystems through flexible duct. The required mass flow to be supplied will be 10,000 kg/hr. This air mass flow will be pumped with high static pressure blower to various terminals for satellite & vehicle cooling through two parallel insulated aluminum round ducts.

Functional Requirements/ Specifications

S.NO	Parameter of air	Required at termination point
1.	Temperature °C	10-15 °C
2.	Relative Humidity %	40±5%
3.	Cleanliness	10,000 class
4.	Static Pressure	Mini :625 mm of water column
5.	Mass flow Rate kg/hr	10,000

- Brine chiller package shall be as follows:
    - Brine chilling package (one working and one standby).
    - Air Handling Unit (one working and one standby), each comprising of primary cooling coil, chemical dehumidifier, high static blower, secondary cooling coil,heaters and filter plenum.

- Capacity of brine chilling plant at SVAB shall have 50% higher capacity than required to take care future requirement.
- Modular vertical beds (MVB) type Dry Air make using silica gel desiccant fully automatic digitally controlled dehumidifier equipped with control panel for continuous monitor and regulates all relevant parameters. The LCD shall display reactivation temperature, operating status of the reactivation heater, fans and bed motors, fault and operation status. Remote control is also to be incorporated
- Separate duct for 2/3 interstage shall be laid with provision of change over from cool air to cool nitrogen.
- Nitrogen will be cooled by separate heat exchanger located in dehumidifier room.
- The cooled, dehumidified and filtered air from Air Handling Unit to terminal points will be supplied through insulated aluminum duct at around ten terminals at various elevations.

- Once through air conditioning shall be provided for SVAB.
- Air handling unit shall have provision of coil by-pass arrangement.
- There shall be two separate round aluminum insulated required size duct from filter plenum to SVAB with interface termination at different levels. One for vehicle cooling and other for satellite cooling.
- All duct terminations shall be provided with flow control/adjustment manual wheel operated damper with locking arrangement
- The air velocity in duct shall be maintained with in 10 m/sec for designing the round duct
- Hot well and Cold well tank shall be of RCC construction to accommodate the chilled brine (-1) ° C.
- Motors rating shall be 10 to 20% above the BKW de-rated for the ambient condition of 45°C.
- All outdoor units shall be designed to with stand 250 kg/m² wind pressure and earth quake. (Factor zone –II as per IS- 1893)
- Chiller will be horizontal shell and tube type construction with brine to flow in the shell and the refrigerant inside the tubes.
- Refrigerate -22 shall be used in refrigeration system.
- Ethylene glycol shall be used for brine preperation.
- The air - cooled condenser shall be constructed of copper tube, mechanically expanded in to aluminum fins.
- Air entry shall be from bottom and discharge at top with help of propeller fan with motor and supporting frame to with stand saline atmosphere and outdoor duty.
- A/C ducting construction will conform to: 655, 2006. Ducting of satellite and vehicle cooling and ducting inside UT will be aluminum.
- Chilled brine pipeline up to sizes 150 mm dia. shall be MS, E.R.W black, heavy class and as per IS: 1239, Part-I: 2004. Brine pipeline in sizes 168.3 mm. shall be MS, E.R.W black and as per IS: 3589, 1991 and pipe thickness will be 6 mm.
- Refrigerant pipeline shall be of MS black, heavy class and as per IS: 1239, Part-I : 2004.Pipe fitting up to 150mm dia. Will conform to IS: 1239, Part-II: 2011.
- Cast iron butterfly type manual valve will be provided at brine pipe line for isolation.

- Ducting of satellite / vehicle cooling will be cold insulated with Mineral wool / Rock wool in molded section. The insulation material will be in two halves of annular cylindrical shape to match the circular duct size.
- Chilled brine pipe line for satellite cooling system / Refrigerant pipeline will be cold insulated with phenolic foam / PUF / Isoloyd. The insulation material will be in two halves of annual cylindrical shape to match the pipe size.
- Horizontal centrifugal pump with back pull out design shall be provided. Pump shall be coupled with motor by spacer type coupling.
- Pump shall be fitted with mechanical seal instead of gland to avoid any leakage. Pump casing, cover and impeller will be of cast iron construction.
- The pump shall be heavy duty suitable for continuous duty and shall be standard product of the manufacturer proven for satisfactory & reliable performance.
- The pump shall conform to the latest edition of the standard.
- AC plant along with AHUs shall be interfaced for remote operation, monitoring and control from AC plant and from LCC/MCC six km away from launch pad.
- The contractor shall be responsible for design of all material, equipment and services which are not specifically mentioned but are required for completeness of the system, safe operation and to meet the functional requirement.
- All the equipment supplied and installed shall be fully compatible with each other and capable of operating as a fully integrated system to deliver the specified output under design conditions
- The heat exchanger having required capacity shall be interfaced to brine cooling system to chill the gaseous nitrogen. Interface shall also be provided for indoor air parameter and quality monitoring.

2.3 DDC system for SVAB Air Conditioning & Satellite Cooling Systems

Functional Requirements/ Specifications

- The system offered shall be completely modular in structure and freely expandable at any stage.
- Each level of the system shall operate independently of the next level up.
- The system shall fully consistent with the latest industry standards, operating on Windows XP or later, allowing the user to make full use of the features provided with these operating systems.

- The centralized air conditioning plant shall be remote monitored / operated / controlled from centralized control room located in plant control room. This shall be the man / machine interface.
- DDC System of SVAB shall perform the following functions:
    - Local status indication of equipment like compressors, pumps, AHU blowers and condenser fans.
    - HP/LP/OP and low chilled water temperature cut-out switch to off the compressor and local indication for the same.
    - Temperature gauge at pipeline to monitor chilled water temperature.
    - Automatic operation of three way motorized mixing value at AHU outlet line to control room temperature.
    - AHUs of bay cooling room will have humidity control arrangement by strip heater. The strip heater will be interlocked with safety Thermostat.
    - Heater / pan humidifier which will be put at AHU outlet duct. The strip Heater / pan humidifier will be interlocked humidistat and will be operated in case of high / low humidity respectively. Strip heater and pan humidifier will be provided with safety thermostat.
    - Automatic capacity control of compressors with variation of cooling load.
    - Explain tank high and low water level alarm. Makeup water tank high and low water level switch.
    - Low differential pressure switch (at chiller inlet and outlet connection line) to off the compressor and local indication for the same.
- DDC System of Satellite Cooling system shall perform the following functions:
    - Remote operation (start/stop/reset) of equipment like compressors, pumps, AHU blowers and condenser fans.
    - Remote start/stop/status of reactivation heaters.
    - Remote start/stop/status of black strip heater located in SA path.
    - Remote status indication of equipment like compressors, pumps, AHU blowers/dampers and condenser fans.
    - HP / LP / OP and low chilled water temperature cut-out switch to off the compressor and remote compressor trip alarms for the same.
    - Remote monitoring of chilled brine temperature at common outlet header of chillers.

- Automatic operation of chemical dehumidifier for humidity control of supply of processed air.
- Automatic capacity control of compressors with variation of cooling load.
- Remote control and monitoring of temperature and RH of UT cooling air at various levels.
- Remote control and monitoring of temperature and RH of satellite cooling.
- Remote monitoring of static pressure of satellite cooling air at end point.
- Manual cum motorized ON-OFF type butterfly type damper at inlet brine line to each chiller.
- Motorized ON-OFF type butterfly type damper at outlet duct to each Blower of satellite cooling AHU.
- Automatic operation of 3 way motorized mixing valve at AHU / heat exchanger outlet line to control supply air / N2 temperature.
- Hot well and cold well high and low liquid level alarm at low level.
- Low differential pressure switch (at chiller inlet and outlet brine connection) and remote alarms for the same.

3.0. AUXILIARY UMBILICAL TOWER AND CRYO ARM

3.1 Auxiliary Umbilical Tower

3.1.1 Purpose

Auxiliary Umbilical Tower (AUT) is mainly intended for accommodating Checkout equipment for Launch vehicle and payload, providing routing of pneumatic, electrical and cool air umbilicals inside and their terminations on the front side (vehicle side) of the structure and to interface cryo arm at different levels.

3.1.2 Description

The Auxiliary Umbilical Tower is a vibration and EMI isolated, modular steel structure of varying area of cross section and 57 m overall height. AUT is basically a steel structure of width 10 m, depth 6 m at the base level. It is provided with necessary connections to attach with the existing Mobile Launch Pedestals. All sides are permanently closed with steel other than the rear side which has doors for inside access. Floors are provided inside the structure at required levels. A simple stair case/ ladder is provided inside AUT for access to these levels.

3.1.3 Specifications

- AUT should have floors inside the structure at about 4.0 m interval, preferably matching with the floor levels of the SVAB
- Preferably made of three or more modules so that handling and modification to suit future launch vehicles is easier
- The rear side of the AUT should have openable doors at various floor levels. The locking and hinge arrangement of the doors should be such that they sustain the launch environment.
- Acoustic and EMI proof and air-conditioned enclosure is provided to safeguard equipment during checkout and launch activities. The materials have to thrive in the high temperature launch environment on the one side and nitrogen purging from inside for critical equipment.
- It has to be interfaced with the existing MLPs with a simple handling and attachment mechanism.
- It should support the cryo arm and the allied repositioning and actuation mechanisms.
- Provision is provided to reach various levels and locations through staircase and cat walks.
- Protecting all equipments and devices inside AUT during operational wind of 18 m/s.

- Cutouts should be available for routing the satellite cooling duct of sufficient flow rate.
- The front side of the AUT should have cutouts for terminations of umbilicals
- AUT front face should be coated with thermal paint to enable the structure to sustain launch environment
- Trays must be available to route the cable of electrical and checkout system
- Providing suitable interfaces for fixing CCTV cameras at convenient height at 4 corners of working floor levels.
- It is required to provide interfaces for the following sub-systems which are described elsewhere in this document.
    - Connection to the mobile launch pedestal
    - Air conditioning, Satellite cooling systems
    - Checkout cables and terminations
    - Helium, Nitrogen and compressed air supply systems
    - Electrical power supply, distribution, aviation lamps
    - Earthing and lightning protection system
    - CCTV and communication network
- AUT shall be designed for the following loads
    - Cyclonic wind loads corresponding to 180 kmph (3 sec gust) at 10 m height (as per IS : 875 latest revisions and enhanced by a factor of 1.3 as per IS 15498) with K1 : 1.09 (25 years life span, 5% risk level), K2 : For category -1 & class - C structures and K3 : 1.0
    - Seismic loads for zone III as per IS : 1893
    - Live loads due to personnel & equipment
    - Axial, lateral, vertical loads and moments of the floors (dead weight+ live load of 200 kg/m^2 UDL & 1500 kg tip load and the dead weight of the floor) shall be considered for the design.
    - Jet loads on the front face as well as on the top surface resulting from largest vehicle amongst the launch vehicles considered. This is of the order of 0.05 ksc distributed uniformly.
    - Loads due to the doors and associated drive mechanisms (dead weight+ wind loads)
    - Load due to cryo arm and dynamic load due to its actuation by mechanical or hydraulic means

3.1.4 Proposed configuration

- The stand-off distance from the vehicle centre is maximum of 8.0 m at the base level and increases to 12.0 m.
- At the bottom, AUT is 10 m x 6 m. Its cross section tapers down to 6 m x 2 m at 31.0 m EL.
- The taper gradient should be less so as to allow smooth flow of launch vehicle exhaust gases.
- Since the AUT seems to be a dynamically sensitive structure, sufficient care should be taken to provide vortex spoilers at appropriate locations.

The proposed configuration of AUT is shown in **Fig 10**

3.2 Cryo Arm

3.2.1 Purpose

To support the cryo stage umbilicals during filling and retract them at/just before vehicle lift-off to a safe distance along with separated umbilical connection unit (UCU) without collision to vehicle parts. It will also provide a mechanism for UCU forced separation as redundancy to the natural / pyro separation.

3.2.2 Description

The cryo arms are retractable cantilever structural booms with repositioning provision. Two Nos. of arms, one for fuel (LH2) and the other for oxidizer (LOX) will be provided. The retraction of arm will be in horizontal / vertical plane using suitable retraction mechanism i.e. counter weight / hydraulic / pneumatic drive. The connection of arms to cryo stage is by means of linkage mechanism to provide relative displacement between the vehicle/stage and cryo arm. Forced separation system will be provided to pull the ground half of UCU as redundancy to the pyro separation. The cryo hoses & cables, which are to be connected to stage, will be routed on the arms by suitable clamping/fixing arrangement.

3.2.3 Requirements/ Specifications

- Arm structure and mechanism shall be configured considering the interfaces with AUT, cryo hoses terminations, stand-off distance with vehicle, orientation of umbilical on vehicle and the repositioning arrangement for drive.
- Selection of drive shall be such that it ensures arm retraction to get min. 8.0m radial clearance from vehicle /strap-on centre within stipulated time.

- Repositioning arrangement shall be provided in the common areas for servicing cryo stages of different vehicles. The arm and linkage configuration shall take into account this aspect.
- Arm structure and retraction mechanism shall be designed for the following load cases:
    - Operating wind loads (30m/s wind speed)+ weight of flexible hoses + Mechanism loads for mated condition
    - Launch wind loads (18m/s) + Weight of flexible hoses + Mechanism loads for mated condition
    - Launch wind loads (18m/s) +Weight of flexible hoses + Mechanism loads + Forced separation pulling force + Vehicle gas dynamic loads during dynamic condition
- The connection of umbilicals /flexible hoses to the ground lines as well as to the stage shall be configured with properly oriented loops to prevent twisting/stretching of hoses during arm retraction. Also the loop provided for flexible hoses connected to stage shall take care of flexibility in mutual displacement zone.
- The operation of linkages collapsing to create gap between vehicle and separated Umbilical Connector Unit (UCU) shall be highly reliable and interference free with vehicle parts/ strapons.
- Arms shall be retracted to get minimum 8 m standoff distance from vehicle/strap-on centre in 3.2 sec (i.e. retraction of around 50 deg. in 3.2 sec)
- The retraction shall be highly reliable, smooth and impact free.
- Limit switches and cables shall be provided to feed signal to control room to indicate the arm position (i.e. for retracted, mated and parking position).
- Elaborate factory tests and dynamic analysis has to be formulated to evaluate the operational reliability and collision free movement of vehicle with arm by demonstrating the withdrawal time.
- The connection between the arm and vehicle shall provide flexibility to take care of mutual displacement of $\pm$ 200mm in horizontal plane and $\pm$ 100mm in vertical plane.
- Lateral load on UCU/vehicle from each arm shall not exceed 500kg in mated condition and 1000kg during forced separation
- Forced separation of UCU by vehicle movement shall take place within 200mm of vehicle travel if the arm retraction is at lift-off.

- The linkages are to be automatically locked with cushioning effect after collapsing to limit position to prevent rebounding probably using telescopic links.
- The tentative details of pipe lines and cables that are to be routed through the cryo arm are given below:

Pipelines on oxidiser side (LOX)	15 nos. Total weight (including wt of brackets and clamps for pipe supports: 2000 kg approx
Pipelines on fuel side (LH2)	19 nos. Total weight (including wt of brackets and clamps for pipe supports: 2000 kg approx
Pyro and pressure sensor cables	4 nos. (20 mm dia) on each arm

Required support brackets and clamps are provided on the structure to fix the pipes, cables and the flexible hoses.

Vehicle data:

S. No.	Parameter	Variants of GSLV	GSLV-MKIII
1.	UCU level:	EL43250 to EL 43700	EL 32793
2.	No. of umbilical units	2 (one each for LOX & LH2)	
3.	Orientation of UCU on either side of vehicle	22.5 deg.	45 deg.
4.	UCU separation plane with reference to vertical	33 deg.	33 deg.
5.	Core diameter	2900	4000
6.	Strap-on diameter	2100	3200
7.	Max. lateral load on vehicle in mated condition at the time of forced separation	1000 kg	1000 kg
8.	Time of UCU separation	T + 350 to 670 milli-sec. (at lift-off)	T-6 sec. (Prior to lift-off)
9.	Weight of cryo hoses	2000 kg	2000 kg

3.2.4 Proposed configuration:

The configuration has the following salient features:

- Configuration : *Horizontal, front folding with double hinge.* One of the pivots of the arm is connected to a stationary support frame. This support

frame, together with the front boom, back boom and the link member forms a four bar chain mechanism.

The UCU hood shall be connected to the front boom by removable fasteners for minor orientational and translational adjustments.

- *Drive : Hydraulic rotary actuator / counter weight*

  Hydraulic Drive: For a hydraulically actuated drive, the pivot on the support frame is keyed to a gear. This gear is mated to two racks constrained to move in opposite directions by hydraulic linear actuators having criss-crossed inlet ports. The linear operation of the piston actuated racks will impart rotary motion on the arm pivot for mating/ retraction. Retardation and end cushioning arrangement is provided.

  Counter Weight: For the arrangement described in the configuration, an electric motor will provide the drive through a set of gears for swing-in. A locking arrangement will prohibit the cryo arm from separating from the vehicle under the action of the counter weight. This lock is pneumatically or hydraulically operated (remotely) at the time of launch. For retraction, a rope will connect the front boom at the extreme end and the support frame. Beneath the support frame, the rope carries weights that can move along guides provided on the sides of the AUT. At the fully retracted condition, the counter weights shall be supported by shock absorbers.
- Retardation : Hydro-mechanical buffer
- Cryo hoses mating : At cryoarm level

The configuration is shown in **Fig. 11 and 12**

4.0. WHEEL BOGIE

4.1 Purpose

Wheel bogie is meant to support the MLP at its bottom during its movement from SVAB to launch pad or to storage area. It consists of four nos. of wheel bogie units at four corners

4.2 Description

A four wheel bogie system consisting of four nos. of 1.2 m diameter wheels mounted on bearings and connected by means of one hinged balancer and two nos. of axles with oscillating block is planned. The system ensures equal load distribution on all the four wheels of the bogie. All the bogies are interconnected by means of a frame structure, which can be disassembled from MLP structure. When MLP is stationary it is on anchors and the bogie structure is removed and positioned in storage area. The bogies are provided with braking system for stopping the MLP during its movement. Each bogie is provided with the hydraulic jack for lifting the MLP while transferring the loads to anchors or vice versa. All the four jacks are operated using the power pack system mounted on bogie frame structure. The power pack system comprises of two power packs interconnected and each power pack is capable of operating all the four jacks.

4.3 Functional Requirements/ Specifications

- The bogie shall support the total dead load of the MLP, equipment loads, vehicle loads, live loads and wind loads caused due to structural interactions and support settlement.
- The bogie is capable of carrying the MLP at controlled speed at a wind velocity of 18 m/s. The wind may be acting from any direction.
- It is necessary to stop MLP smoothly by applying brakes on bogie wheels.
- The jacking system capable of lifting the MLP along with the vehicle by means of hydraulic jacks for transferring the MLP on to anchors and vice versa shall be provided on the bogie.
- The bogie shall have suitable interface to attach MLP at its bottom, similar to the existing system at SLP

4.4 Proposed Configuration

- Bogies are designed to carry the heaviest of the MLPs
- Capacity of each bogie : 500 t

- Location of bogies below MLP : at corners of 14 m square
- Width of track : 14 m C/C
- Distance between twin rails : 750 mm
- Tread diameter of wheels :1200 mm
- Load carrying capacity of each wheel : 150 t
- For ascertaining the workmanship, one wheel need to be destruct tested.
- No. of wheels in each bogie :4
- Load equalization system is provided for all the wheels comprising of one hinged balancer below which two axles with oscillating blocks are provided.
- To enable the bogie to negotiate curved track, a slew bearing shall be introduced between the balancer and top oscillating block.
- Pneumatic/hydraulic shoe brakes are to be provided for wheels and shall be actuated from drive system. Suitable interface (hooks) shall be provided on either side of the bogie system for push/pull operation using hauler.
- The power pack and the generator (whose specification shall be finalized) are mounted on a trolley attached to bogie frame.
- Double flanged wheels shall be provided to take all lateral loads in case skew control is not proposed.

JACKS

Jacks and power pack shall be imported and of reputed make. The jacks are located one each as part of each bogie

- Capacity of hydraulic jack : 600 t
- Stroke : 150 ± 5 mm
- Closed shut height : 700 ± 10 mm
- Type : double acting
- Ram : screwed type with lock nut provision
- Operation : remotely operated from power pack
- Saddle: max diameter 300 mm swiveling type with anti skid top surface
- Hose connection: from power pack to the jacks, hoses of high pressure thermoplastic type of suitable length are to be provided. The end connections

shall be of QC/DC type with male connection on the jacks and power pack end.

- Size of cylinder : Maximum of 500 mm OD, size of the ram, operating pressure can be suitably designed to accommodate the overall sized as given above. Test pressure shall be 1.5 times the design working pressure.
- Rate of lift or lowering under load: 10 mm/min
- Outside surface of ram and inner surface of cylinder shall be honed and hard chorme plated to a thickness of 50 µm.
- The seals should be reliable and everlasting type.
- The locknut on the ram shall be designed to take care of the full load and overload
- The inlet valve to the jack shall be pilot operated type to take care of hose failure.
- One pressure gauge has to be fixed at the jack to monitor the cylinder pressure.
- The jack shall be mounted on a suitable trolley for easy maneuverability inside the wheel bogie.
- The hydraulic oil used shall be fire retardant.

POWER PACK FOR JACK OPERATION

- Two power packs are interconnected and each shall contain a pumping unit with hydraulic high pressure radial plunger type piston pump operated by flame proof electric motor. Split flow piston pump with two identical outlets is preferred.
- The oil tank shall have an oil level indicator, oil filter cum air breather, return line filter, drain plug etc.
- The power pack also shall have safety relief valves, non return valves, oil distributer with flow control and shut off valve with inlet to pump and outlets to four jacks.
- Flame proof DOL starter and cable of suitable length shall be provided.
- Provision for supplying oil to the pilot operated check valve near jacks to be made.

- The power pack shall have a manual pumping provision with quick interchange facility. The manual pump shall operate with effort less than 35 kg and shall provide the rated lift in 5 min of pumping.
- Each power pack shall simultaneously operate four jacks of capacity 600 t each with stroke length of 150 ± 5 mm and the rate of lift for all jacks shall be maintained equally. A pump with two identical outlets can be used with a provision to bypass any one outlet for operation of one jack only.
- The power pack shall supply oil under pressure for operation of pilot operated check valve.

The location of bogies with respect to the overall MLP structure is shown in **Fig 13.** General arrangement of wheel mounting on the axle and the pin connections are shown in **Fig 14.**

5.0. TWIN RAIL TRACK & FOUNDATION

5.1 Purpose

The fully integrated launch vehicle has to be moved from SVAB to Second Launch Pad or Third Launch Pad on a Mobile Launch Pedestal. To meet this requirement, a sturdy track capable of taking MLP wheel loads are to be laid between SVAB and SLP. For future expansion of the track, it will be extended to the Third Launch Pad.

5.2 Description

The track forming part of the SVAB Project shall be same as the existing track at the SLP. This is a twin rail track with the gauge of 14 m and distance between the rails on either side being 750 mm. The area between the rail tracks is to be paved with RCC road to enable movement of the hauler used for MLP traction. Pill boxes are provided along the track for monitoring the movement of MLP along with the vehicle through CCTV. Suitable lighting is provided on both sides of the track.

5.3 Functional Requirements/ Specifications

- The track shall be designed to provide leveled top surface for smooth movement of MLP.
- The difference in levels of top surface of track due to deflection under load shall be minimum to maintain the stability of vehicle.
- The track shall have slope to take Mobile Launch Pedestal to Launch Pad which is at 1.2 m above the SVAB floor level.
- The track shall be designed for a bogie wheel load of 150 t
- Centre to centre distance of twin tracks is 14.0 m and distance between twin rails is 750 mm.
- Level difference across tracks between rail tops at any location to be limited to ±1 mm.
- The proposed track has to intersect with the existing SLP track at some distance from the launch pad. A similar intersection has to take place also outside SVAB. A suitable track arrangement needs to be developed for the track changeover.
- The track changeover should be simple, reliable and quick operating.
- A mechanism has to be provided to rearrange the track if the weight of the track segments is found too heavy for manual operation.

- The foundation of the track shall take into consideration the increased width of track including the bolster plates, levers etc. of the actuation mechanism.
- The design of the rail track shall take into consideration the loads encountered and the condition of the soil at the proposed location
- The track proposed for SVAB is curved with a radius of curvature of about 600 m. There shall be no rubbing of the wheels on the edges of the track which may give rise to vibrations or cause any detrimental effect on the bogie wheels or the track.
- A cable trench shall be provided along the track with track crossing in front of the building
- RCC road with drainage provision shall be planned between the rail tracks.
- The rail is of flat, heat treated type MRS 85- 171 lbs/yard as being used at SLP and FLP.

The track layout is shown in **Fig. 15** and the configuration of rail track with foundation details are shown in **Fig. 16 & 17**

6.0. HAULER

6.1 Purpose

The hauler is meant to haul the MLP with or without the vehicle on it between the SVAB and launch pad and to the storage area.

6.2 Description

The hauler to be used for MLP shall attach to its side and haul it. This will be used for dual purpose of hauling the MLP and also as a material handling equipment for transportation of material and launch vehicle systems/stages.

6.3 Functional Requirements/ Specifications

- It shall have sufficient tractive effort to haul 2400 t by wheel bogie on a rail track.
- Its operation should be smooth, jerk free and precise.
- The acceleration and deceleration of the hauler should be limited to a maximum of 0.003g (0.03 m/s^2).
- It shall have a payload capability, for carrying, of about 600 t.
- It shall be of self loading and unloading type with a stroke length of atleast ±300 mm.
- The hauler shall have easy maneuverability around the corners of roads.
- An interface shall be provided on the existing MLPs to attach the tow bar to them for hauler.
- The vibration levels of hauler shall be minimal so that no vibration is transmitted to the launch vehicle.
- The hauler shall be operated in either 'push' or 'pull' mode with about the same tractive effort in either mode. It shall also be able to move in both forward and reverse directions.
- The scope of contract also includes the design of a tow bar for connection between the MLP and the hauler such that it can impart the motions mentioned above.
- The suspension shall be such that equal load is transferred to all the wheels irrespective of the maneuvering direction, road level and gradient.
- Since the load to be carried is high, sufficient ballast weight can be placed on the hauler to avoid tyre slippage or freewheeling.

- To arrive at the tractive effort, the following loads shall be assumed on the hauler:
    - The load of the MLP+ launch vehicle +AUT+ bogie+ self weight of hauler shall be considered, which works out to be about 2400 t.
    - Wind load at 18 m/s acting on the entire frontal area of vehicle, AUT, MLP and bogie.
    - Frictional force of the entire MLP stack moving on wheels over a rail track.
    - Frictional force of the hauler tyres with the road
    - The above loads are to be considered both for dry and wet conditions.

6.4 Proposed Configuration

It is proposed to procure a Self Propelled Unit of enough tractive capacity and use it for the hauling of the MLP. In order that the tyres of the SPU do not slip on the road, a ballast weight is placed over the SPU.

The intended mode of usage of SPU for the purpose of hauling the MLP is depicted in **Fig 18**

7.0. ELECTRICAL SYSTEMS

7.1 Definitions

Electrical Systems: The power distribution scheme of the SVAB and associated equipment which ensure reliability, availability and clean power within acceptable tolerance limits to the SVAB and associated facilities fall under the electrical systems of SVAB. This is categorized into two forms of electrification i.e., external electrification and internal electrification.

7.2 Description

External Electrification: Constitutes establishing of suitable capacity sub-station if required with the equipments such as transformers, DG sets, HT & LT switch gear panels, UPS systems, batteries and battery chargers and outgoing cable feeders to SVAB and its associated facilities.

Internal Electrification: Constitutes MV panels, MCCs, LDBs, PDBs lighting, area lighting, street lighting, cabling, earthing and lightning protection systems within the facilities including cabling

Auto-changeover: Circuits used for carrying out changeover between two incoming power source feeders in the event of failure of one of the sources and unhealthy conditions like low voltage, phase failure, earth fault on incoming side etc. switching to be accomplished by contactor / ACB depending upon the load connected to the circuit.

7.3 Functional Requirements/ Specifications

External electrification

The power supply can be broadly classified as:

- Normal Power Supply (APSEB Power Source)
- Captive Power Supply (Local DG Source)
- Uninterrupted Power Supply (UPS)
- Specific Voltage Power Supply
- Construction Power and Lighting

It is required to design power distribution scheme based on individual maximum demands of SVAB and its associated facilities to be fed by the sub-station, installation of transformers, HT and LT panels, switchgear protection equipment, earthing systems and outgoing feeders to facilities, centralized emergency lighting systems of SVAB etc. two feeders from two modules of MV panel are proposed to cater the SVAB AC load. The capacities of these feeders need to be designed as per the capacity of AC plants. Lighting load of SVAB and other facilities in the vicinity of SVAB need to be included while arriving at the maximum demand at the sub-station.

7.4 Internal Electrification

Internal electrification is classified into two areas. One is power distribution for illumination, etc and second is power distribution for mechanisms like E O T crane, Platforms, doors, lift etc. of all facilities.

1. LIGHTING &POWER OUTLETS A) Illumination	At all platform levels-Hazardous area classified as group-IIB Around Vehicle: 350 lux at a height of 1m. All other areas: 250 lux in postal area of fixed platforms and 200 lux in catwalks.
A.1) Type of light fittings	Non-FLP fittings at portal areas and panel rooms. Flame Proof group- II B fittings in all other areas.
A.2) Outside Illumination	Non-FLP light fittings on either outer side at a height of around 17m
A.3) Control Switch	In MV panel room with MCB control
A.4) Emergency lighting	Throughout SVAB including catwalks, lifts, staircase, panel rooms, working platforms, fixed platforms etc with CFL/LED lamps. Centralized emergency lighting system to be located at Sub-station and operated with maintenance free batteries
B. POWER Outlets	
B.1) Single phase 16A, 5A flameproof/ Non -FLP plug sockets	Average min 4 nos.of power sockets in each floor on either side
B.2) 3 Phase power outlets FLP/ Non -FLP plug sockets	One number each 32A power sockets in each floor on either side
B.3) 3 Phase power outlets FLP/ Non -FLP plug sockets	One number each 63A power sockets wherever required ie 0,8,38,42,51,60,64 on either side
B.4) Air-circulators exhaust fans, Water coolers	In the portal areas
2. UPS POWER REQUIREMENTS:	Single phase 16A plug sockets at the catwalks on the required levels on checkout rack side

	Single phase 16A flame proof, group-II B plug sockets at different levels One number in each chain on each level.
3. MECHANISM LOADS 3.1) Machine/Equipment	1) Motor control centres for doors and platforms 2) EOT crane 3) Lifts 4) MLP 5) 50% lighting (approx.) and air circulators located near to working platforms
	MD- 300KVA on each feeder from DG Change-over
	Panel- 1 & 2 of TLP substation
	Single phase 16A flameproof plug sockets
	Two nos. on either side at ground level and on all FCVRPs
	3 Phase 30A and 60A flameproof plug sockets
	One each on either side at ground level
4. VENTILATION 4.1) Ceiling wall mounted fans	One each in all rooms and one number of air circulators each on both sides of all FCVRPs
4.2) Exhaust fans	--
5. TYPE OF WIRING	Surface cable. PVC armored cable with copper stranded conductor. Suitable cable tray arrangement to be planned in all area
6. POWER SOURCE	SVAB S/S for normal supply. TLP s/s for UPS and DG supply
7. EARTHING(Static/Power/Lightning)	YES, as per standard practice
8. LIGHTNING PROTECTION	Shall be provided with verticals on the roof of SVAB with horizontal conductors suspended over the length and with suitable down conductors which provides 30 degree cone of protection.

Construction power supply

Construction power and lighting requirement shall be met from required number of 11/0.433 kV pedestal mounted transformers, suitably located on site. Considering the long period of construction activities, proper design of the construction power receipt and distribution with adequate protection & metering shall be planned. Safety in the construction site is of paramount importance.

8.0. EOT CRANE AND ELEVATORS

8.1 EOT Crane

8.1.1 Description

A 400/60 t capacity flame proof EOT crane is proposed in SVAB and is provided at an elevation of 82 m to meet the handling requirements. The crane shall have a LT provision of 43.5 m and CT provision of 22.5 m to meet the integration requirements. Crane shall be operated from any floor below 82 m using plug-in type pendent.

8.1.2 Functional Requirement/ Specifications

- Crane has to safely handle the Sub-systems of the launch vehicle received at ground in vertical or horizontal condition.
- Dual drive control system (VVVF Drive control) shall be provided for all the motions. In case of failure of one drive system, the crane should be operable without any problem.
- Crane hook shall have a reach to the closet point possible from all side walls / doors to handle various hardware items. However, both the hooks shall reach up to a distance of 6m from the walls on all sides.
- The brakes shall be effective and accurate to stop the crane within a very short distance and in a safe and smooth manner.
- The crane shall have precise control/movement to align the parts for integration with variable speeds (VVVF Drive control).
- Crane shall be operable from any floor using plug-in type light weight pendent (one spare pendent should be supplied).
- SVAB crane shall be operated from pendant control at 21 platform levels at different elevations. The platforms are located at elevations of 0.0m, 4.5m, 9.0m, 13.0m, 17.0m, 20.0m, 24.0m, 27.0m, 31.0m, 35.0m, 38.0m, 42.0m, 47.0m, 51.0m, 55.0m, 59.0m, 63.0m, 67.0m, 70.0m,74.0m, 78.0m and 82.0m.
- Dual rope system shall be provided and each shall take SWL of the crane.
- Hydraulic operated Disc brake system shall be provided for hoist motion (Emergency brake should act directly on the wire rope drum).
- The EOT crane shall have the following technical parameters:

Type	:	Double girder indoor type
Duty class	:	Class 2 as per

		IS:807-1067/ IS:3177-1977
No. of trolleys (Crab)	:	One
Operating Levels	:	Aprx 18 working platform levels using 2 Nos of plug in type intrinsically safe pendants from both sides at each level
Safe working load		
Main hoist	:	400t
Auxiliary hoist	:	60t
Highest position of hooks above top of floor level		
Main hoist	:	82.0 m
Auxiliary hoist	:	82.0 m
Gap between the centers of crane LT rail and nearest side obstruction	:	0.5 m
Height of the crane from the hook at maximum lift position to the topmost point in the crane (lesser height is preferred)	:	6.0m (max)
Spring level of SVAB	:	78.0 m
Level of gantry girder rail for LT	:	72.0 m
Operational speeds		
Hoisting speed max (Main & auxiliary)		
With load	:	3 m / min
Without load (empty hook)	:	6 m / min
Creep speed	:	0.3 m / min
Long travel speed		
With min load	:	3 m / min
Creep speed	:	0.3 m / min
Cross travel speed		
With min load	:	3 m / min

		Creep speed	:	0.3 m / min
Power supply				
	Voltage			415 V ±10%
	Phase			3
	Frequency			50 Hz ± 5%
	Combined variation voltage and frequency			10% max. (Absolute sum)

- Head room of minimum 2 m must be available above the 400/60 t EOT crane for maintenance works.
- The crane shall be provided with dual rope system which is hot dip galvanized with independent wire rope core and non- rotating type.
- Electrical contactors shall be suitable for 300 starts/hr (AC4 duty).
- Intrinsically safe junction boxes and plug sockets shall be provided on either sides of the platform level. Two numbers of portable trolley type, intrinsically safe, multi-pin plug-in type light weight pendants shall be provided along with a lead cable of 30 m length to plug the same at any of the plug sockets at various platform levels. Light weight pendants with interlock arrangement shall be provided.
- Each hook block shall be operated on ball or roller thrust bearings and shall rotate freely. Ramshorn hook for 400 t and C hook for 60 t capacity and shall also have safety latches.

ELECTRICAL:

- Motors shall be of increased safety. Main hoist motor may be of crane duty squirrel cage/slip ring type, all other motors shall be squirrel cage crane duty type. For slip ring motor 15% excess capacity can be considered where as for squirrel cage motors it shall be 30%.
- The motor insulation shall be class F for hoist and class B for other drives tropicalized by coating with non-hygroscopic coatings, suitable for operation in sea shore area.
- Main control panel shall be provided in electrical panel room of SVAB with sufficient working space all around, panels shall be of IP 55 enclosures. Cabling shall be fire retardant, low smoke, armored and tinned copper cable.
- VVVF control with IP 55 enclosures is to be provided. Similarly, twin or four-corner drive is to be provided for LT drive with a mechanism of speed synchronization on both sides of LT.
- The festoon cable maintenance cage shall not interfere with guide columns.

- In case of multiple drives either for CT or LT speed synchronization shall be provided. In such cases individual drive shaft shall be designed to take the full load.

BRAKES:

- The brakes shall be operated using electro-hydraulic Non-FLP thrusters. Hoist motion shall be provided with redundant brake. All thruster brakes shall be reliable and imported.
- Disc brake shall be provided for hoist motion.

DESIGN:

- Crane structure shall be designed in accordance with IS: 807 with its latest edition / revision.
- Mechanical, electrical, inspection and testing requirements shall be in accordance with latest IS: 3177.
- All electrical equipment and fittings shall be suitable for ZONE-I operation as per IS: 5572. Enclosures wherever specified shall be of IP55. Intrinsically safe apparatus and circuits, wherever specified, shall belong to category I B and shall be as per IS: 5780. The temperature classification shall be T4 of IS: 8239.
- Crane shall also be used to tilt the sub-systems received in horizontal condition to vertical. During tilting, LT motion of the crane shall be used along with the tilting fixtures. This is to be taken to account while configuring the orientation of rope drums.

DESIGN AND STRUCTURAL CONSTRUCTION
GENERAL

- In the design of components on the basis of strength, factor of safety shall not be less than five (5) based on ultimate strength, impact, fatigue, wear and stress concentration factors shall be taken into account. Wherever applicable
- The crane shall be rigid in construction and all movements shall be smooth and non-jerky.
- Design shall provide for easy maintenance of all parts particularly the wheel bearings on end-trucks. Necessary safe and sufficient working space shall be provided all around the sub systems for easy maintenance.
- Where any portion of the structure is not free to expand or contact under variation of temperature, allowance shall be made for stress resulting from these conditions and the co-efficient of expansion for each degree centigrade variation of temperature above and below normal being taken as 0.000012 for mild steel. The maximum range of variation of temperature

shall be given. Clause 8 of Section II of IS: 800 – code of practice for us e of structural steel in General Building construction shall also apply.

- For load carrying members the component plates, bars, angles and other rolled sections the minimum thickness shall be 4.9mm (6 SWG). For unsealed tubes the minimum thickness shall be 8 mm. The chequered plates for platforms shall be of minimum 6 mm thick.
- Unless otherwise specified, only welded joints shall be used. Where welding is not practicable, turned and fitted bolts shall be used. Connection between carriages and main girders shall be by means of machined bolts fitted in reamed holes. Minimum number of turned and fitted bolts in connection shall not be less than two.
- Transverse fillet welds on load carrying members shall be avoided. If side fillets are used in end connections, the length of each side fillet should not be less than the edge distance between the fillets.
- Splices shall be designed to resist one and half times the forces and moments to which they are subjected to, but in no case it shall be less than 2/3rd of the effective strength of the material spliced except that splices in the webs of the plate girders shall be designed for full strength of the web in shear as well as bending. For splicing tension members, the net section of the splice plate shall be ten percent more than that of the material spliced. Splices shall be proportioned and arranged, so that the gravity axes of the splices are in line with the gravity axis of the member to avoid eccentricity.

RUNWAY / TROLLEY RAILS

- The rail section shall be as per IS: 3443

BRIDGE GIRDER

- The crane shall be of double girder type.
- The bridge girder shall be of box section. The exterior surface shall be smooth and free from projections, so as to minimize dust collection on it.
- Breathing holes shall be provided in completely enclosed welded box type girders. Drain holes shall be provided at all places where water or oil is likely to collect.
- Wherever practicable, means of access shall be provided for inside inspection of completely enclosed box girders.
- In bridge girder strength calculations, the trolley rails and chequered plates shall not be considered as load carrying members.

RULING DIMENSIONS & RATIO

- For compression members, the slenderness ratio shall not exceed 120. In case of other load carrying members and subsidiary members the

slenderness ratio shall not exceed 180.

- For girders, the following values of maximum span to depth ratio shall be governing:

  Plate girders : Span/Depth= 18

  Lattice girders : Span/Depth=12

DEFLECTIONS AND CAMBER

- The total maximum vertical deflection of the girders for the live load plus trolley and not including impact or dead load of the girder shall not exceed limit of span /1000.
- The girders shall be cambered by an amount equal to the maximum deflection due to dead load plus one half the live load and trolley

SHEAVES

- The sheaves shall be of cast iron as per IS: 210 Gr 25. The design shall confirm to IS: 3177

BEARINGS

- All bearings of the gearing shall be anti-friction type. Angular contact ball or taper roller bearings shall be used wherever necessary. The bearing shall correctly locate the shafts while allowing for thermal expansion of the shafts.
- Provision shall be made for service lubrication of all bearings. Bearing enclosures shall be designed to exclude dirt and prevent leakage of oil or grease.

COUPLING

- All couplings shall be of steel of grade 25 of IS: 210-1970 and shall be designed to suit the maximum torque that may be developed.
- Wherever necessary gear couplings shall be used between connecting shafts. Positive locking by means of gib headed keys or end stopper plates shall be provided. To prevent axial displacement for all couplings keys shall be so fitted and screwed that they cannot work loose in service.

SHAFTS & AXLES

- Unless otherwise stated, materials of construction of shafts/axles shall be as per EN 8/BC 970 or equivalent.
- Wherever components of considerable amount of inertia is directly mounted on the high speed shaft (e.g. brake drum, couplings, etc.) they shall be balanced dynamically to minimize vibrations.
- Provision shall be made to prevent the sliding of the keys from their respective key ways during operation. Wherever feasible gib head keys shall be used.

GEARING

Gearing shall be as per IS: 3177 and also as for the following:

- Gears in the speed reducer unit for bridge drive, all hoists and trolley drive, shall be enclosed in substantial housing and shall operate in oil bath. The oil shall have additives of approved quality and shall be of approved viscosity at standard temperature (say 60°C). The housing shall be of sufficient design not to permit a temperature in excess of 90°C of the oil bath and shall be adequately supported. Housing cover shall be easily removable without disturbing gear assembly.
- Gears and pinions shall be of forged steel and machine cut. Gear and pinion teeth shall treat for resistance to wear. All gears and pinions shall be ground type so as to reduce noise levels to the minimum. The permissible noise level is 70 dB at I m distance from the gear box.
- Spur and helical gears shall be used for reduction gearing.
- Mounting of the gears shall be such that axial thrust on the bearing is minimal. Centre distance of the connecting shafts shall be as close as possible to the theoretical value. Shafts shall be designed to keep their deflections within permissible limits.
- The planetary gear boxes shall be of foot-mounted type and of approved make only.

LIFTING HOOK BLOCK ASSEMBLY

- The lifting hook block assembly shall be point hook / Ramshorn with adequate capacity and shall be of forged steel construction. Each hook shall be supported on ball or roller thrust bearing and shall rotate freely on its bearing by manual operation. The lifting hook shall have a safety latch.
- A gravity actuated pendulum type verticality indicator shall be incorporated to the hook block.

BRAKES

- Non – Flame proof type thrustor brakes of suitable rating to stop the crane within a very short distance and in a safe and smooth manner. They should be equally effective in both directions. The thrustor brakes shall be operated by electro hydraulic thrusters. The brakes shall apply automatically when power to drive motor is cut-off or fails.

Service Brake

- Double –Shoe type service brake shall be provided for each motion of the crane. These brakes shall be directly applied automatically to the motor shaft when power supply to the drive motor is cut-off or fails. The brakes shall be equally effective in both directions of rotation. Two brakes each rated for 1.5

times of motor rated torque/ suitable capacity shall be provided for hoist motions of both hooks.

- Service brake for hoist motions shall be adequately sized to arrest and hold at rest any load up to and including test load at any position of the lift. For hoist motion, redundant brake is required to be provided and the capacity shall be such that each brake can satisfactorily meet the requirements of the braking.
- Brake drum shall be positively locked in position so as not to prevent lateral movement by means or retainer plated or any other means.
- Thrusters shall have reserve of at least 30% stroke length available for necessary adjustment as well as provision for adjustment of time for upward and down ward travels of the piston.
- All brakes shall have smooth braking capability to decelerate in safe manner to avoid any derailment even when applied at maximum speed. The braking action of hoist motion shall be such that there shall not be any jerks for the objects being lifted at main speed.

Emergency Mode operation

- An emergency stop pushbutton shall be provided in the intrinsically safe pendent. On operation of this push-button all electro-hydraulic brakes shall be applied immediately to all motions.
- Each hoist motion shall be provided with self-contained, sturdy, automatic braking system to prevent over speeding of the hoist. These over speed brakes may be mechanical load brake type, AC regenerative or DC dynamic type as per standard of the manufacturer.

MOTORS

The requirements of crane motors shall be of either increased safety or flame proof electric motors suitable for the operating environment given in the respective specifications of the individual cranes.

- All crane motors shall be totally enclosed, fan cooled type.
- Motor enclosure shall conform to the degree of protection IP-55
- Each motor shall have requisite capacity for intended service. The increased safety hoist motors shall be rated to lift 125% of the design load on the hook at main speed. The inertial rotating load shall include the rotor portion of creep motors also.
- Main hoist motor may be of squirrel cage/ slip ring type, all other motors shall be squirrel cage type. For slip ring motors 15% excess capacity can be considered where as for squirrel cage motors it shall be30%. The increased safety motors shall be designed for crane duty requirement of frequent starting, reversing and braking. The motor pull out torque shall not be less than 2.20

times rated torque.

- Motor shall suit the duty Class S5, cyclic duration factor 40% and number of starts per hour 300.
- All increased safety motor with rating 30KW and above shall be provided with space heater, sized to maintain motor internal temperature above dew point when the motor is idle.
- In the hoist motion, where empty hook drive is specified, if the main motor is in the drive link during the operation of the empty hook drive, the main motor shall have the capacity to rotate at higher speed of empty hook drive motor without any damage to rotor windings of main motor with sufficient margins.

CONTROLLERS AND REDUNDENT CONTROL SWITCHES

- Fully magnetic control shall be provided for hoist motion, long travel and cross travel motions, complete with contactors, time lag relays, resistors and other accessories to meet the control requirements given in specification.
- Flame retardant control cables from the crane shall be brought out by festoon cable arrangement to a junction box located near the LT rails. The control cables from this junction box shall be connected to suitable intrinsically safe junction boxes with multi pin plug sockets and hinged covers to be provided at two sides of specified floor levels.
- Portable trolley mounted intrinsically safe, multi-pin plug –in type pendants shall be provided along with a Flame retardant lead cables of 30m length to plug the same at any of the plug sockets at various floor levels. Where more than one pendent is provided for a crane, interlock arrangement shall be provided, so that at any given instant crane can be operated using only one pendent.
- Suitable locking facility shall be provided between the socket and plug such that at no instance the plug can come out of the socket inadvertently. All apparatus and circuits contained inside the pendant push button station, junction boxes, plug sockets etc., shall be intrinsically safe and shall belong to the category I B as per IS:5780. The degree of protection offered by the enclosure to the pendant push button station shall be IP:55 as per IS:2147.
- Push button shall be spring return type, with 2No+2 NC contacts rated 10A 110V AC. Indicating lamps shall be filament type with low watt consumption lamp and provided with series resistor.

8.2 Elevator

8.2.1 Purpose

An elevator is meant to carry personnel and material to various floors of the building.

8.2.2 Description

A goods cum passenger elevator of reputed make with a size of the car 1700mm x 2500mm x 2500mm to travel from ground floor at 0.0 m to 82.0 m with stopping at all floors.

8.2.3 Functional Requirements/ Specifications

- The Elevator shall operate from lower most portion of the Vehicle assembly building EL: 0.0 m to the top level 82.0 m and will be located at identified location.
- The contractor has to provide for the Elevator with and AC elevator motor provided for controlling the speed.
- The elevation of various landing zones and the location of the elevator in SVAB is given **Fig 5**
- The machine Room will be located at the top of the elevator shaft at an elevation of 86.0 m, complete drive, electrical and mechanical control equipment, etc., shall be installed in the machine room. However, the non-flame proof control panel housed inside enclosed electrical panel room at lower level.

The elevator shall be designed, manufactured, tested and installed as per IS: 4666-1980 and IS: 1860-1980 and the technical specifications and special provisions indicated herein.

Operation	:	Selective Collective Automatic Control
Speed	:	0.55 m/s
Car size (inside)	:	1700 x 2500 mm
Inside clear height	:	2500 mm
Well size	:	2600 x 2900 mm
No. of landings	:	22
Bottom most landing	:	0.0 m
Top most landing	:	82.0 m

- The elevator shall be designed for arduous duty conditions and shall be suitable for continuous 24 hours round-the-clock operation.
- All electrical equipments inside Machine room shall be of non-flame proof, all high voltage hoist way equipment shall be FLP suitable for Zone-I, Group-II B and all low voltage systems are of increased safety and a non-flame proof control panel housed inside electrical panel room at ground floor. The

temperature classification shall be T4 as per IS: 8239.

- The electrical works shall be designed for satisfactory operation for 415 V ± 10%, 3 phase, 50 Hz ± 5% solidly grounded system combined voltage and frequency variation being 10% maximum (absolute sum)
- The motor insulation shall be class F or better tropicalized by coating with non-hygroscopic coatings, suitable for operation in sea shore area.
- The maximum roof top deflection of the VAB structure under cyclonic winds, when the elevator is non-operational, is approx. 1/500 of the total height of the structure. It shall be ensured that the elevator and guide system are operational under such an event.
- Necessary safety devices shall be furnished to prevent the movement of the car until the car door and all hoist way doors are closed properly.
- Necessary switches shall be furnished in the car to control the operation of the doors.
- At every landing location and also inside the car, car position indicator shall be provided.
- All fittings inside car shall be of FLP type. Emergency lighting, Telephone, Alarm, Emergency escape, Fan shall be available inside the car.
- All electrical equipments operating on medium voltages (i.e. 230V, Single Phase & 415 V, Frequency 50Hz 3 Phase circuits) in hoist way and cab suitable for zone-I operation as per IS: 2148 Group-IIB with IP-55 enclosure, suitable for zone-I operation as per IS: 5572. All other devices in the hoist way operating on lower voltages shall be having increased safely type. The temperature classification shall be T4 as per IS: 8239.
- Trouble-free performance of the elevator incorporating the operational, controlling and safety requirements, as specified, is to be guaranteed.
- At all intermediate levels up and down call buttons with indicators are to be provided.
- The elevator shall be equipped with all standard safety systems such as Bell and cranking in case of power failure, limit switches, indicators, over speed safety governor for car and counter weight.
- Emergency flame proof light fittings, telephone, Alarm, Emergency escape, fan, etc., shall be made available inside the car.
- Sufficient illumination shall be provided in the hoist way.
- The elevator shall be designed to lift a pay-load of 2 t in addition to weight of the car itself and other accessories.
- The elevator shall travel at a rated speed of 0.55 m/sec.

- The number of wire ropes and size of wire rope shall be so chosen that highest factor of safety is achieved as per standard.
- Every lift car shall be carried in a compete frame of steel which shall be sufficiently rigid to withstand the operation of the safety gear without permanent, deformation to the car frame. The car structure may be of steel with special painting or of stainless steel.
- At least four renewable guide shoes with renewable linings or set of roller guides shall be provide two at the top and two at the bottom of the car frame.
- Necessary provisions shall be made for adequate ventilation of the car Ventilation openings shall be provided in the enclosure walls as per requirement of IS: 4666. A separate switch has to be provided in the car for the flame proof fan.
- The enclosure of the lift car shall withstand a thrust of35kg. Applied normally at anypoint, excepting any vision panel, without permanent deformation. Glass shall not be used in the lift car except for the following purposes:
    i. As covers for certificate
    ii. For lighting fixtures
    iii. For appliances used in connection with the operation of the car and
    iv. For vision panels and mirrors
- It shall be constructed of structural steel shapes securely fastened with steel flooring covered with5 mm thick chequered plate flooring. The platform shall be designed on the basis of rated loads evenly distributed. The car floor shall comprise a smooth non-slip surface.
- Car roof shall be covered with sheet metal to prevent dripping of lubricants from ropes-sheave bearings. The top flooring shall be of steel. A three pin flame proof plug socket with a flame proof switch of head lamp shall be fitted on the top of the car for use during maintenance. Provision for slow speed operation from car top in Up and Down directions in 'Individual mode' shall be made to facilitate maintenance of devices in the hoist way. The roof shall be strong enough to support at least two persons.
- The elevator car shall be provided with one centre opening horizontally sliding type doors.
- Car door shall be made up of steel with final paints to match that of the car. It shall have a clear opening of 1200 mm wide x2100 mm high. Horizontally sliding type steel doors having a clear opening of 1200mm wide x 2100 mm high shall be provided at each of the landings for elevator door.
- Hangers and tracks for car door and each hoistway door shall be provided

suitable material shall be used to minimize noise. Ball bearing rollers or equivalent arrangement shall be provided to take upward thrust of the doors. Suitable devices shall be furnished for transmitting motion from one door panel to the other.

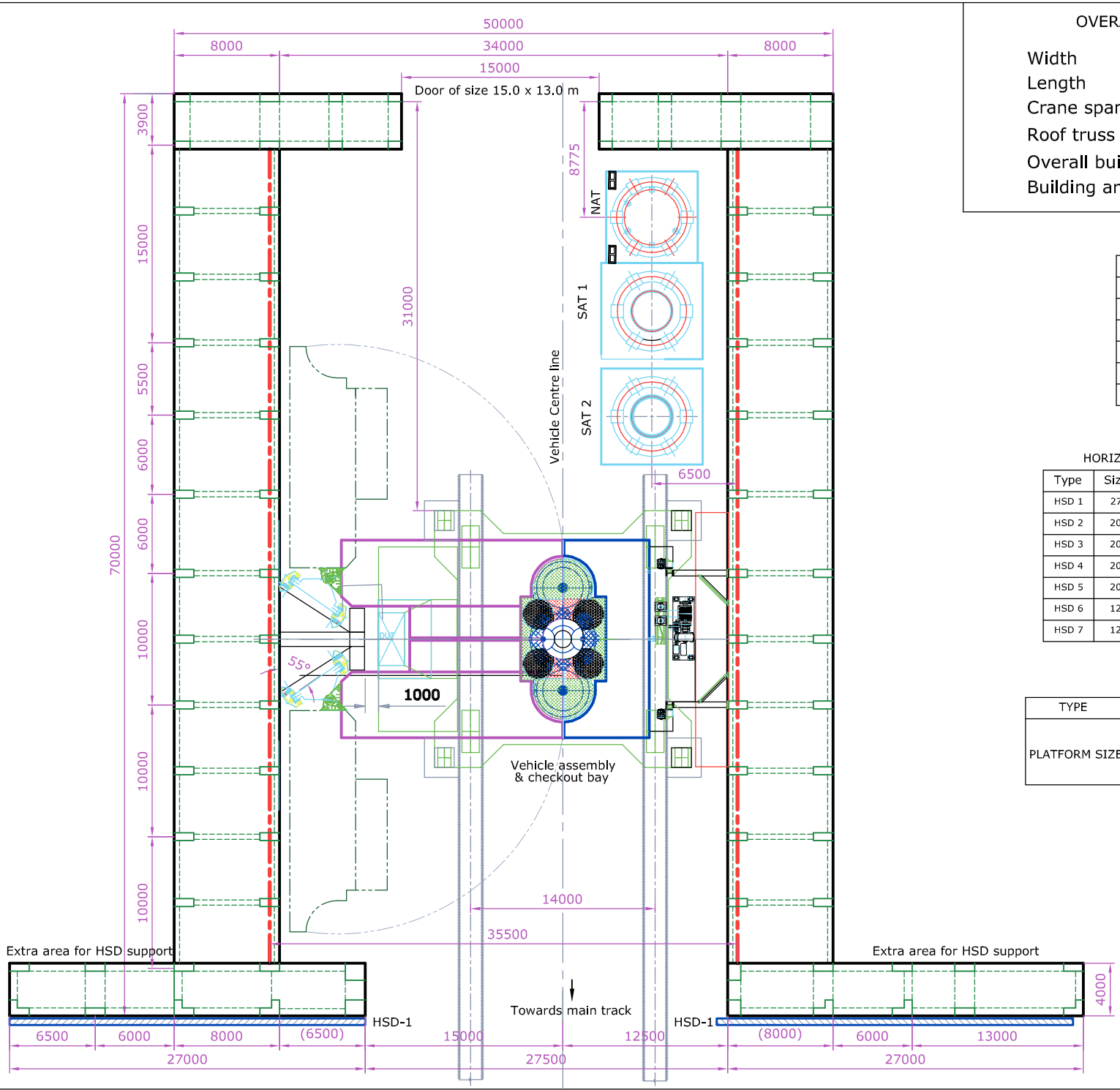
- The required materials for landing entrance, e.g. extruded aluminum or equivalent sills, strut angles, headers etc., shall be provided.
- The doors operation shall be automatic. The door operation shall have power operation, shall have power opening and power closing. Provision of necessary electric type door operators in flame proof enclosures shall be furnished. The car door and the hoistway door shall be mechanically connected and shall move simultaneously during opening and closing. The necessary door cushioning devices shall be furnished.
- The car door and the hoist way door shall open automatically when the car stops at a landing. The door operation shall be so designed that the doors can be manually opened only at landings if the electric power fails.
- The elevator shall be equipped with automatic self-leveling devices to bring the car to the floor landings. These self-leveling devices shall correct for over-travel or under-travel and rope stretch.
- The elevator control, i.e., the system governing starting or stopping the elevator machine, determining the direction of travel, regulating the rate of travel, regulating the rate of accelerating and deceleration, and controlling running speed of the moving member through 3 phase squirrel cage induction motor. The AC drive motor for the elevator shall accelerate or decelerate the elevator according to requirement. Reversal in direction of movement of the elevator shall be achieved by reversing the motor 3 phase supply.
- The operating of the elevator i.e., method of actuating the control shall be selective Collective Automatic Operation' as per clause 2.4.2.3 of IS-1860-1968, with and without attendant. All accessories required for the 'collective operation' as outlined therein, namely selector and its driving type, floor bars with electrical contacts etc., shall be furnished complete.
- In the car, the Contactor shall furnish an operating panel containing push buttons, numbered to the landing served; two position key- operated switch, marked to indicate "with attendant" and "without attendant"; and emergency call button connected to a bell to serve as an emergency signal; push button or switches for fan and other push buttons, switches as required.
- A signal indication shall be provided by the appropriate numeral (which shall be floor level of the respective floor) being illuminated when the car is passing the corresponding floor. The indication shall remain illuminate when the car is stopped at a floor. Up and down direction jewel lights shall also

be provided. The car position indicators are needed to be provided at all landings also.

- A single "Up" or "Down" push button at terminal landings and separate "Up" and "Down" push buttons at each intermediate landing including cal register lights for each push button shall be provided. These shall remain illuminated until the call is answered.
- Safety shoe device shall be furnished on car door. Safety shoe shall extend the full height on the closing edges of the both halves of the car door. The arrangement shall be such that the safety shoe when touches a person or an object while the door is closing, the car and the hoistway door shall return to the open position. In case of actuation of safety shoe, returning of door shoe shall be jerk free thus avoiding damage to door movement mechanism. The doors shall remain open for a predetermined interval and then close automatically.
- The elevator car shall preferably be provided with an emergency exit of adequate dimensions.
- The terminal buffers shall be furnished for stopping the car and the counter. Weight at the extreme ends of travel. All structural steel members required to install the buffer shall be supplied under this specification.
- A load plate giving the rated payload of the elevator shall be fitted in the car in a conspicuous position. The rated load shall be given in kilograms.
- Counter- weight sections shall be mounted on structural metal frames so designed to retain the weights securely in its place.
- Upper and lower guiding members attached to the frame shall guide counter. Weight frames on each guide rail.
- A substantial metal counter-weight guard of required length should be provided at the bottom of the hoist way.
- Car and counter-weight guides shall be rigid steel and shall be continuous throughout the entire length and shall be provided with adequate steel bracings and stiffeners. Guide for both car and counter-weight shall meet the requirements of IS: 4666. The necessary lubrication device for guide rail shall be provided.
- Terminal limit switches for normal operation shall be provided to slow-down and stop the car automatically at terminal landings and final limit switches shall be furnished to automatically cut off the power and apply the brake, when the car reaches the terminal landings.
- The design ambient temperature for these equipment shall be taken a 40ºC. The motor insulation shall be class F or better tropical zed, suitable for operation in sea shore area. The motor should be of S5 duty rating in

case of regenerative or dynamic braking is applied. Space heaters with thermostat shall be provided where necessary.

- Protective relays shall be furnished on the controller to protect against phase reversal, low voltage and phase failure. Overload and other protective replays shall also be furnished for traction motor.
- The controller shall house all equipment accessories required for satisfactory and trouble free operation, protection and control of the lift.
- The controller shall consist of vertical panels, self-supporting and floor mounted type.
- The controller shall be located in the lower most level in such a position as to ensure that there is no possibility of maintenance personnel, while working on the controller, coming into contact with a moving part of the lift.
- All equipment shall be so mounted in the panel that removal and replacement of any equipment may be accomplished individually without dismantling or interfering with other equipment mounted on / within the panel.
- The wiring for the control circuits shall be separated from that of the main power and lighting circuits by running it in separate trucking or conduits.
- Again, for testing purpose a control station shall also be fitted on top of the car and when this is in use it shall not be possible to control the car from any other position. The necessary interlocks for this shall be included. This station shall also have a terminal stop switch and emergency stop switch.
- Magnetic contactors for starting, stopping, etc., shall be furnished and they shall match the duty requirement of the drive equipment.
- The contactors shall be solenoid-operated, air break type.
- Isolating switches shall be triple pole/double pole, air break, heavy duty type, capable of safely breaking the full load current of the associated feeder.
- All fuses shall be HRC, Link type. Rewirable fuses shall not be accepted. Fuse shall have rupturing capacity corresponding to rated system fault level.
- Control circuit shall be protected by individual control fuse (HRC-Link type) of suitable rating.



OVERALL BUILDING SIZE

Width	= 50.0 m
Length	= 70.0 m
Crane span	= 35.5 m
Roof truss span	= 38.0 m
Overall building height	= 96.0 m
Building area	= 3500 Sq m

S & FCVRPs are planned

Platform	Working levels
S & FCVRP 1	13.0 - 20.0 m
S & FCVRP 2	20.0 - 27.0 m
S & FCVRP 3	27.0 - 35.0 m
S & FCVRP 4	35.0 - 42.0 m
S & FCVRP 5	42.0 - 55.0 m
S & FCVRP 6	55.0 - 70.0 m

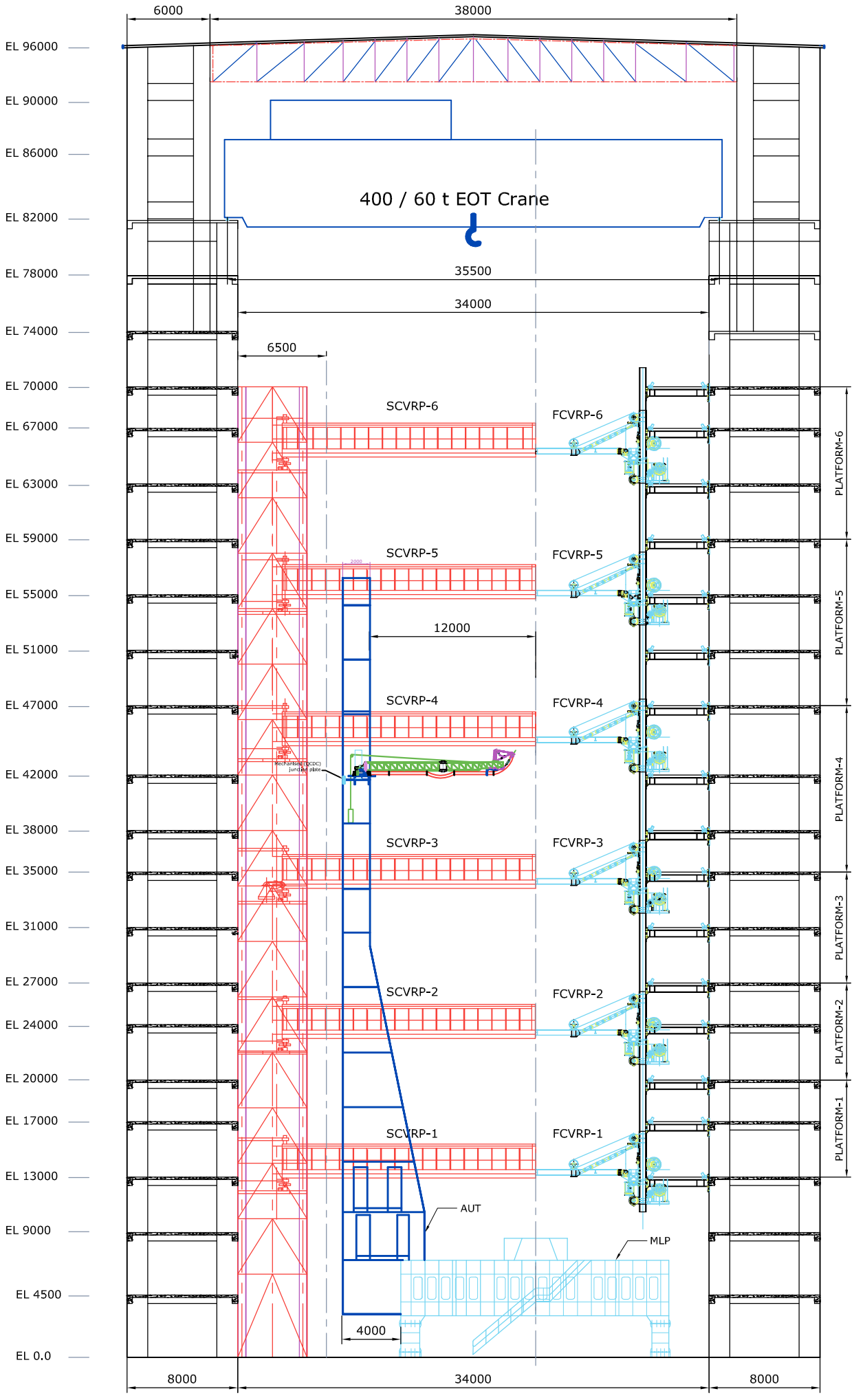
HORIZONTAL SLIDING DOOR DETAILS

Type	Size of door	Open size	No. of doors
HSD 1	27.0 x 13.0 m	27.0 x 13.0 m	2
HSD 2	20.5 x 11.0 m	20.5 x 11.0 m	2
HSD 3	20.5 x 11.0 m	20.5 x 11.0 m	2
HSD 4	20.5 x 12.0 m	20.5 x 12.0 m	2
HSD 5	20.5 x 12.0 m	20.5 x 12.0 m	2
HSD 6	12.0 x 11.0 m	7.5 x 11.0 m	2
HSD 7	12.0 x 11.0 m	7.5 x 11.0 m	2

TYPE	SCVRPs - 6 x 2 Nos.	FCVRPs - 6 Nos.
PLATFORM SIZE	on AUT side	Other side
	~ 16.8 x 7.5 m	6.5 x 15.0 m

All dimensions are in mm

Fig. 1: Floor plan of SVAB



All dimensions are in mm

Fig. 2: Sectional elevation of SVAB

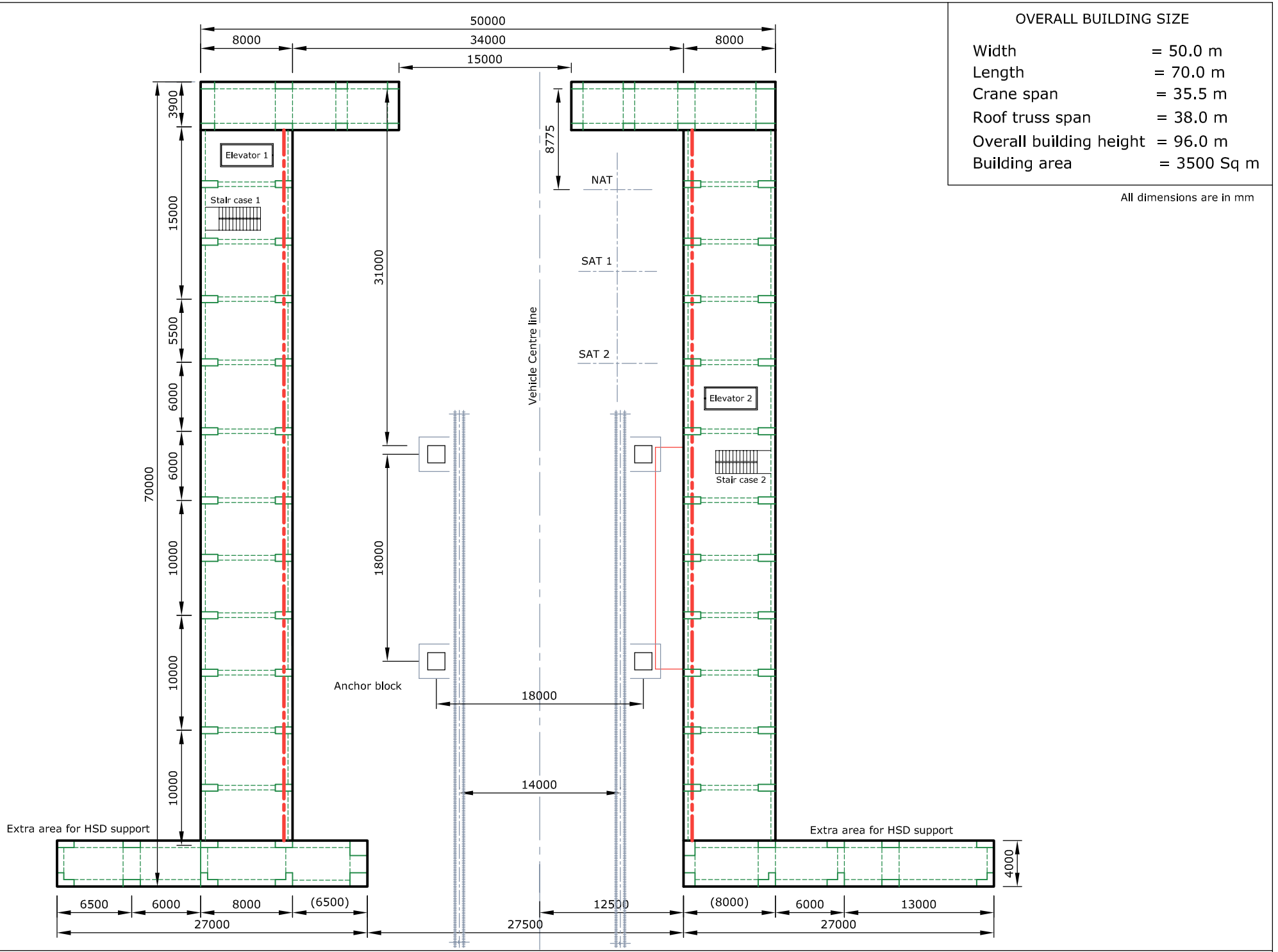
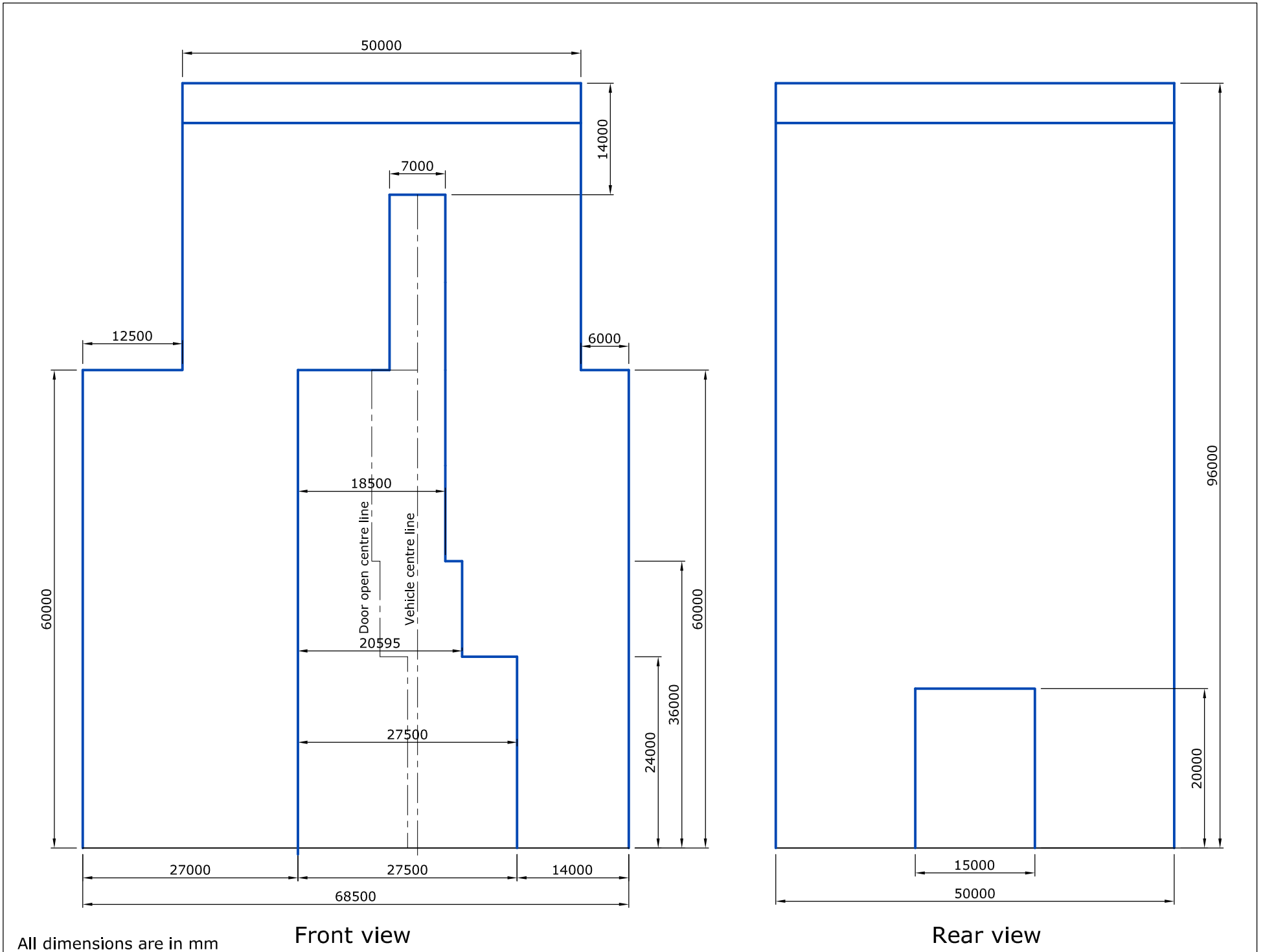


Fig. 3 Floor plan @ EL 0.0 m



All dimensions are in mm

Fig 4 Elevation of SVAB for civil construction

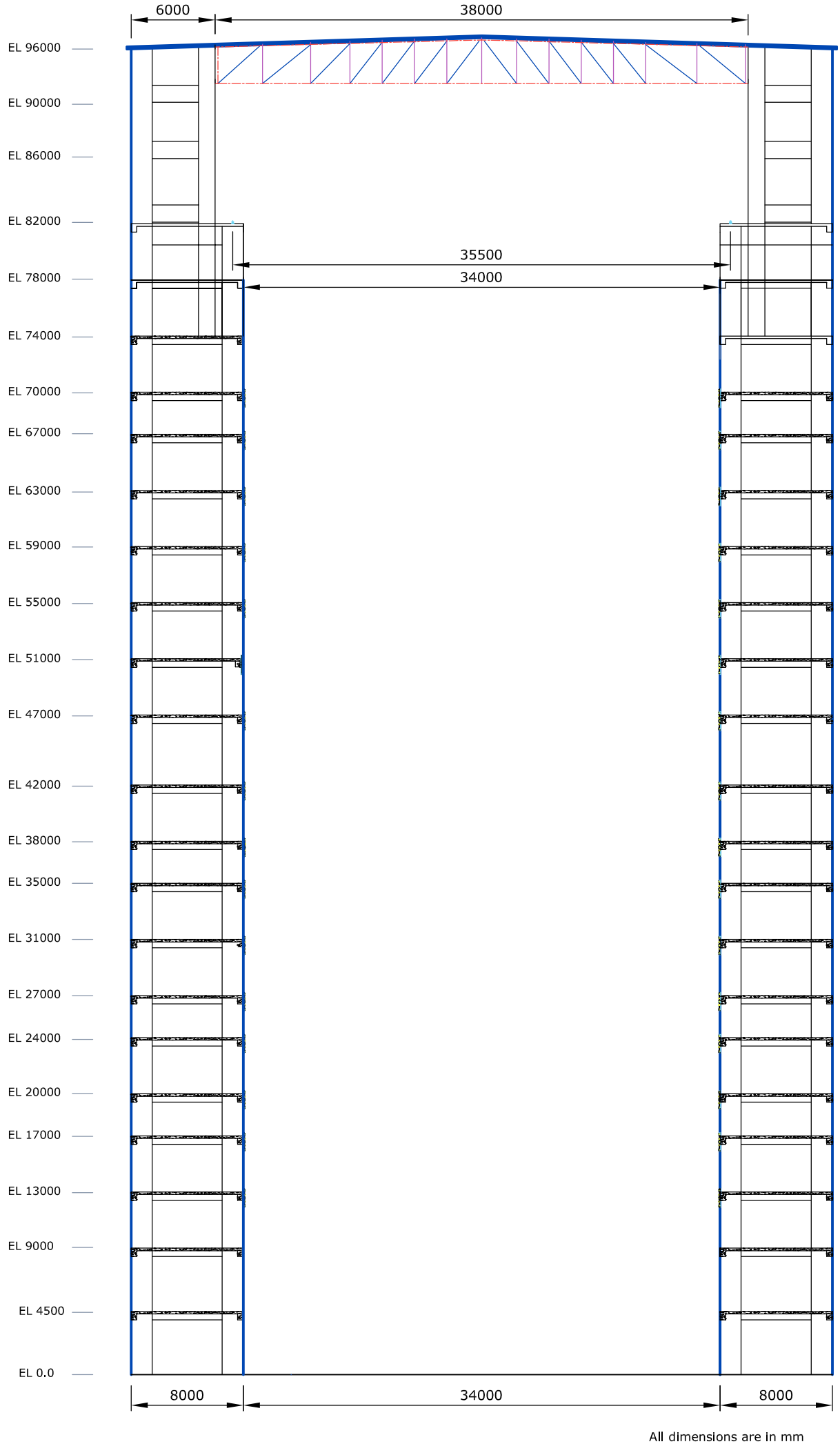


Fig. 5: Sectional elevation of SVAB for Civil construction

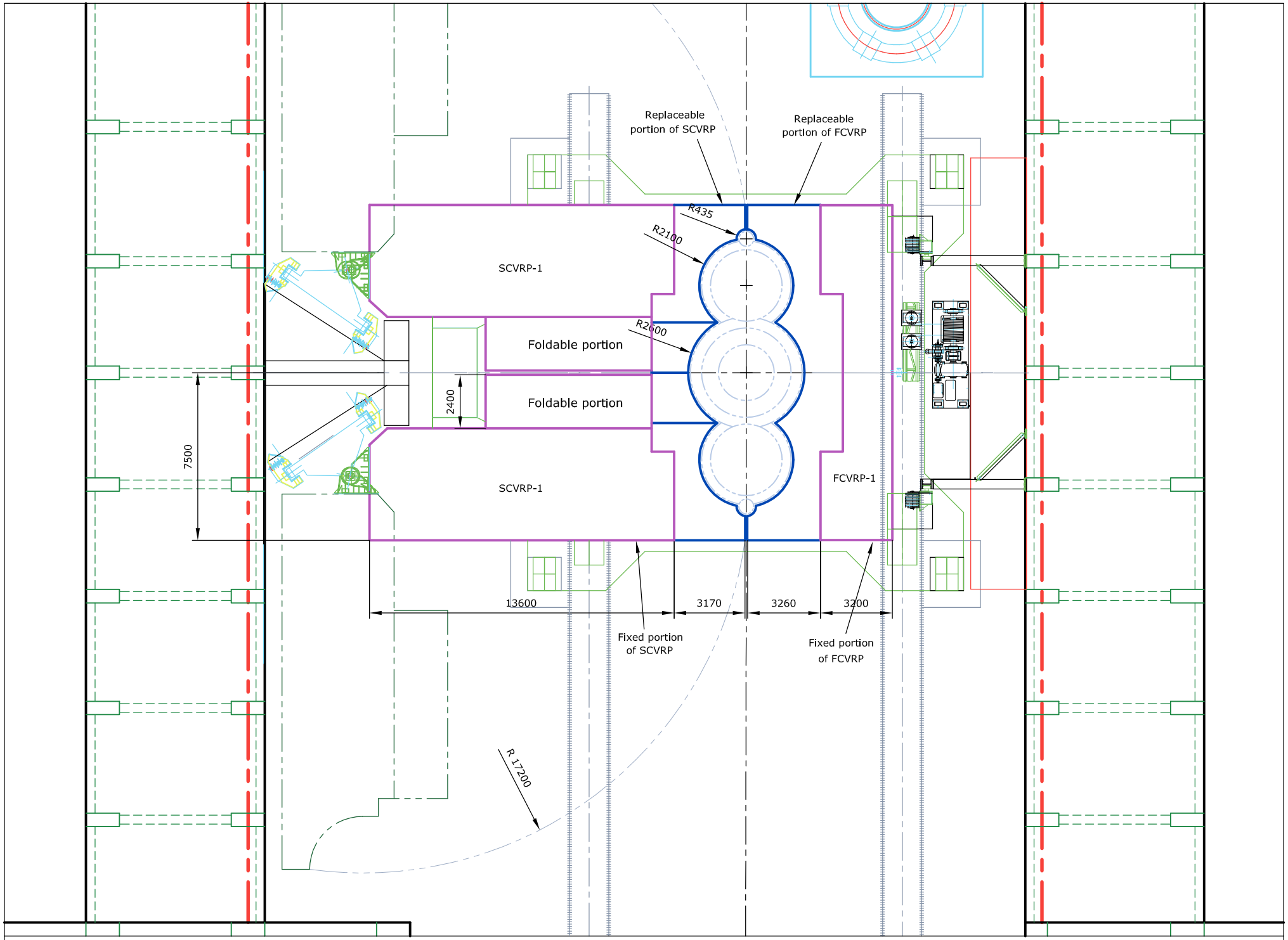


Fig. 6 FCVRP & SCVRP 1 configuration for GSLV-MkIII vehicle at SVAB

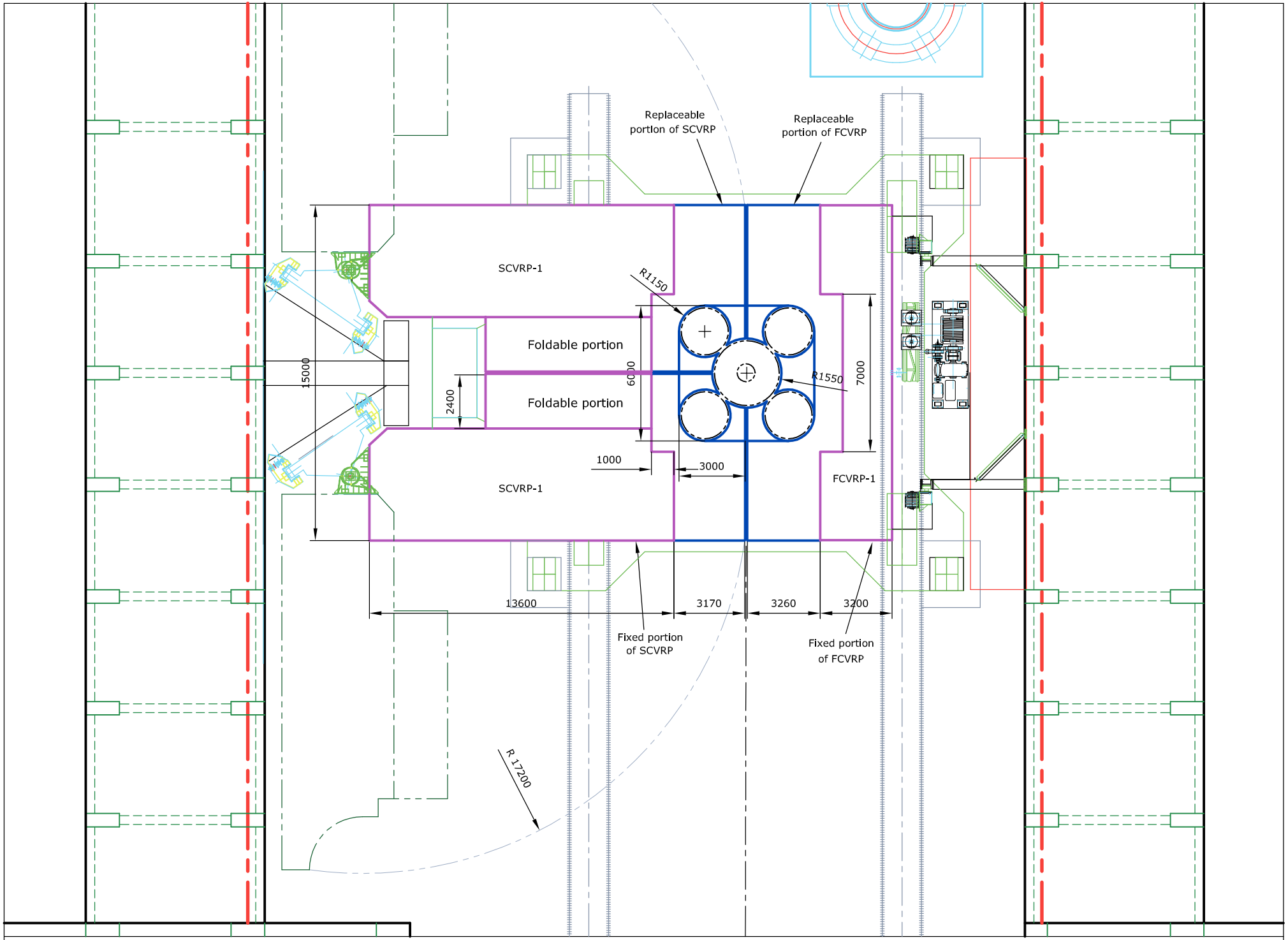
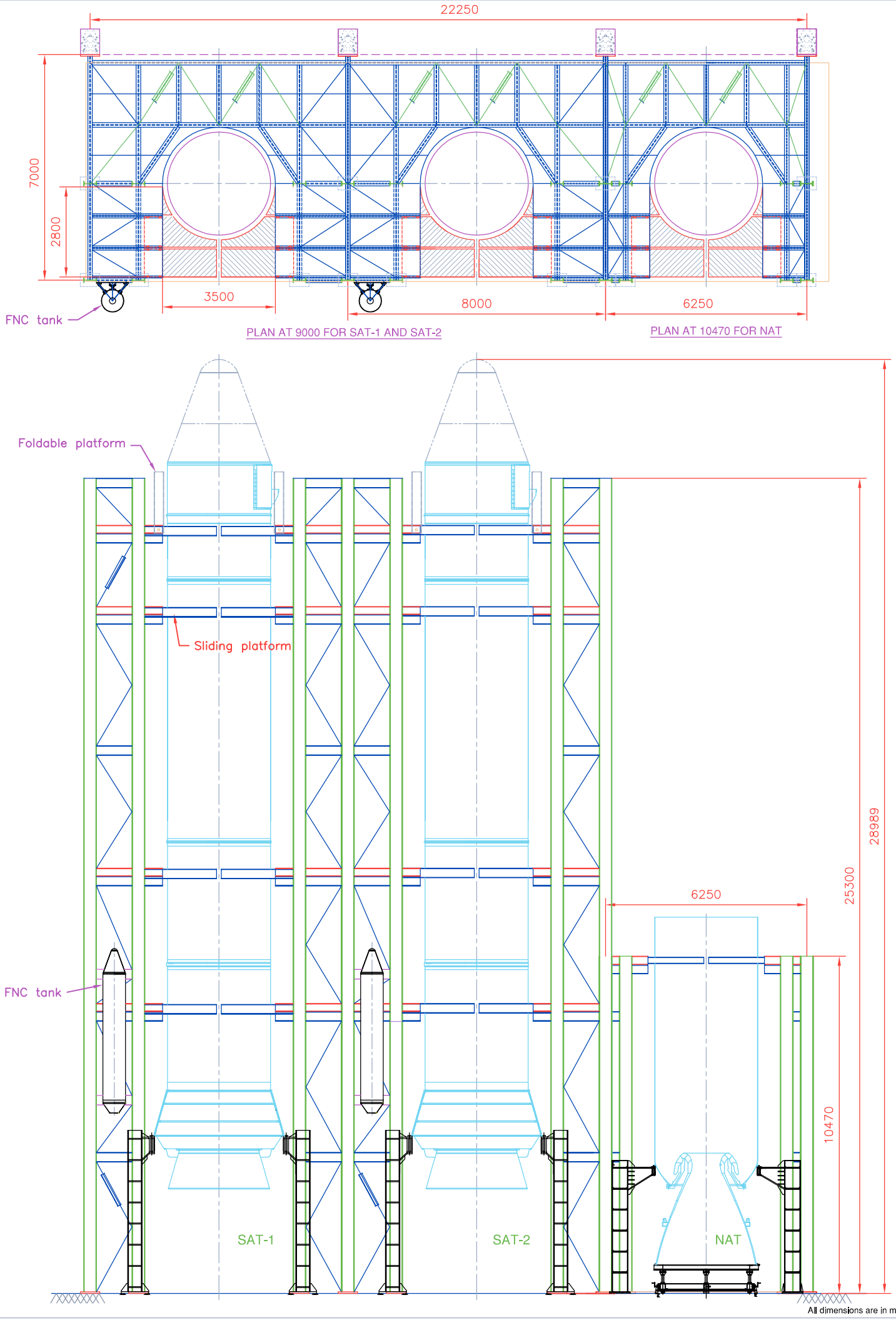
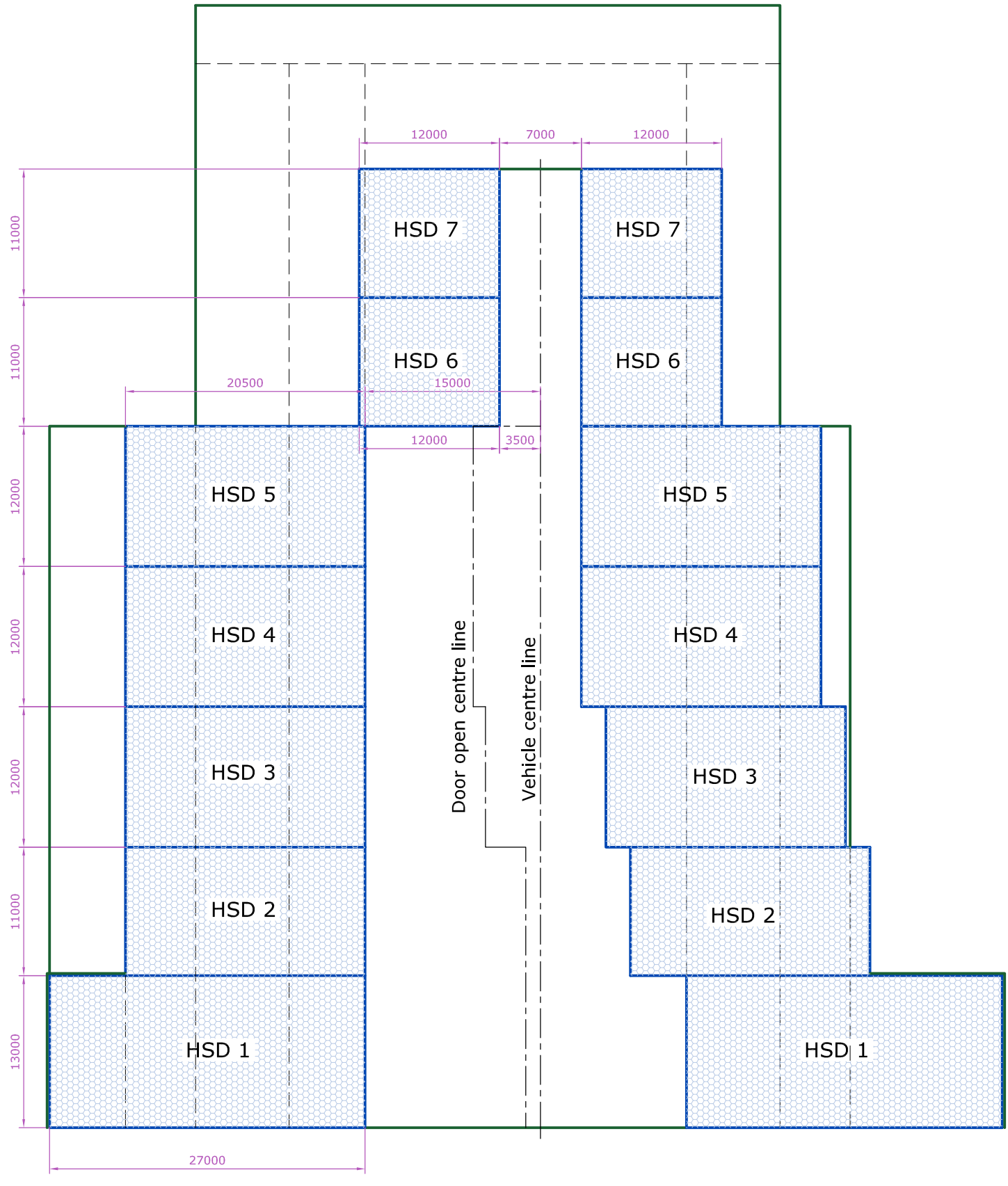


Fig. 7 FCVRP & SCVRP 1 configuration for GSLV-MkII vehicle at SVAB



S200 Segment Assembly Towers (SAT) & Nozzle Assembly Tower (NAT)



All dimensions are in mm

Fig. 9 Elevation of SVAB with HSDs in open condition

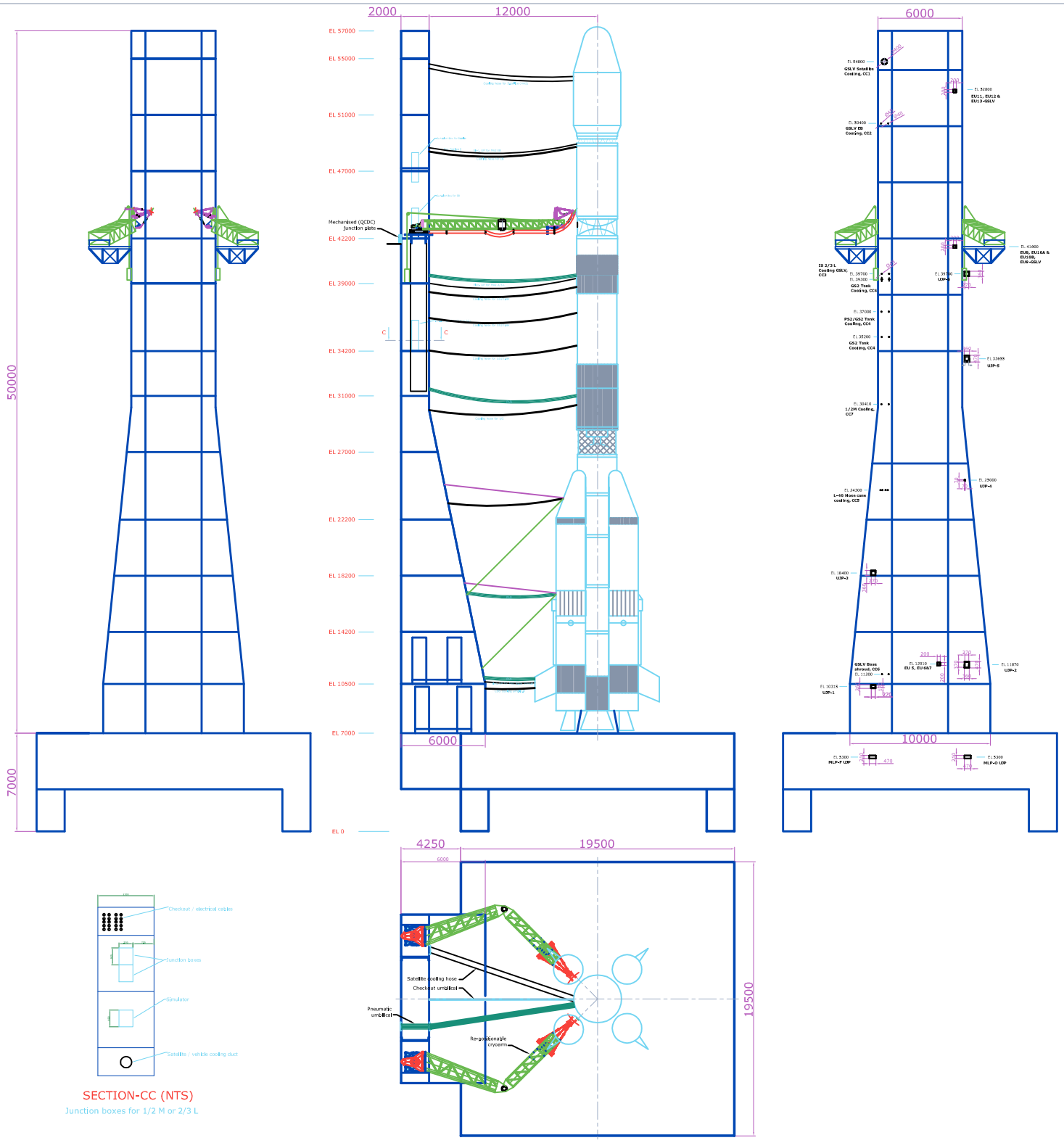
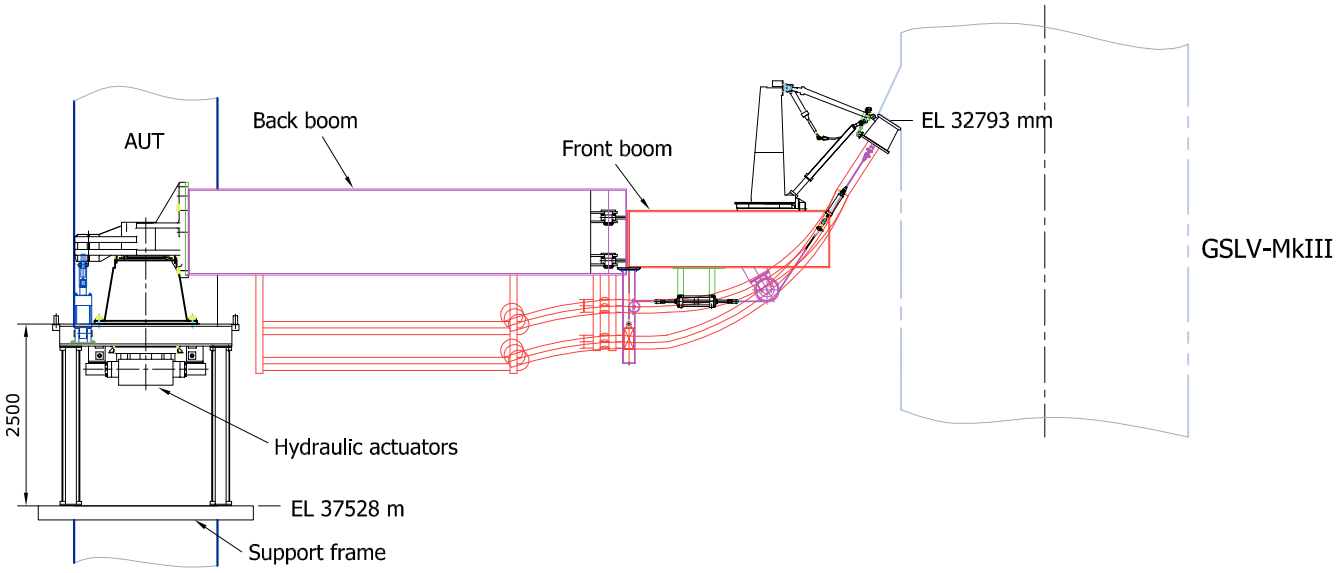


Fig. 10 Auxiliary Umbilical Tower concept



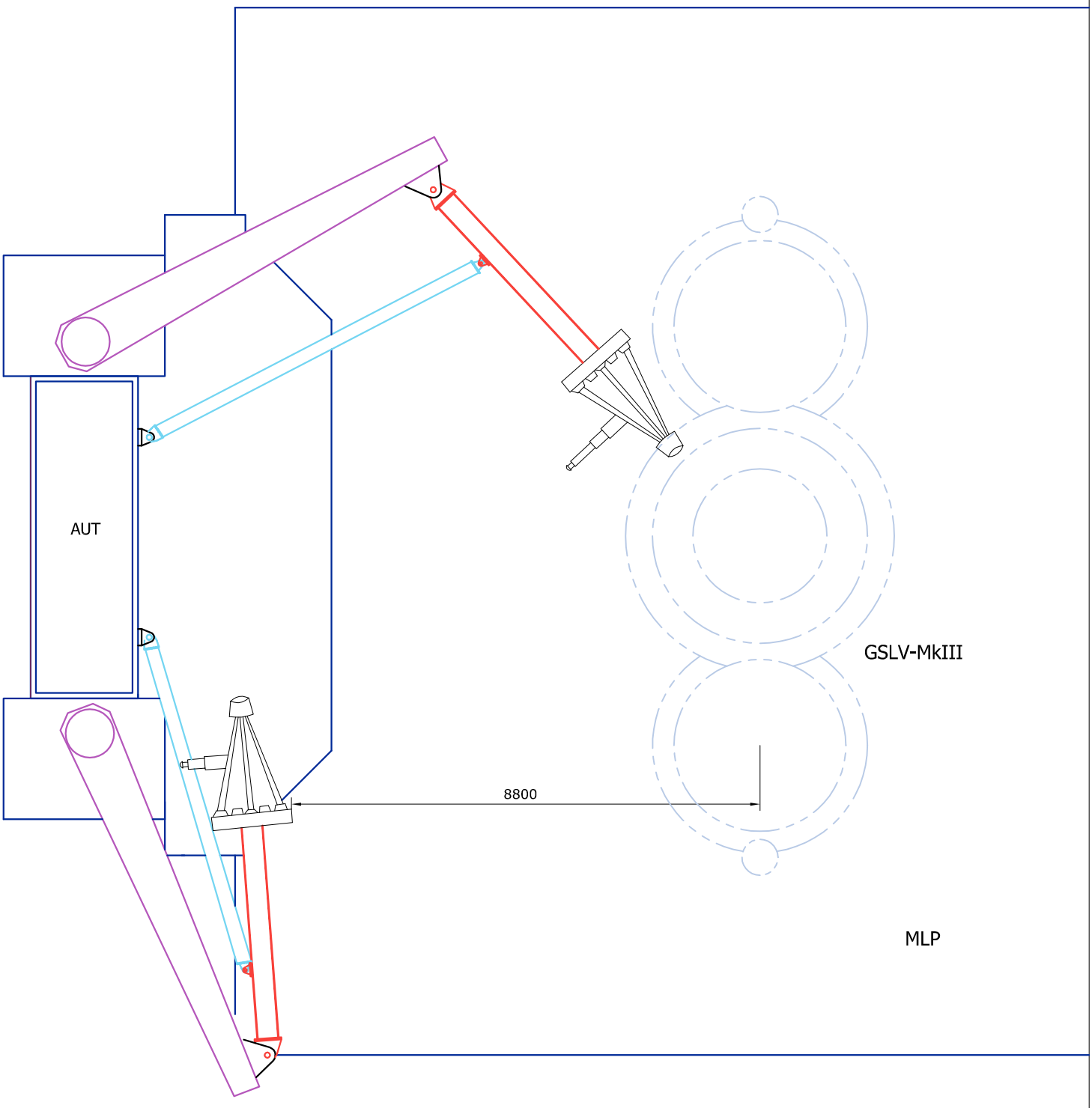


Fig. 11 Cryo arm on AUT (Hydraulic actuation)

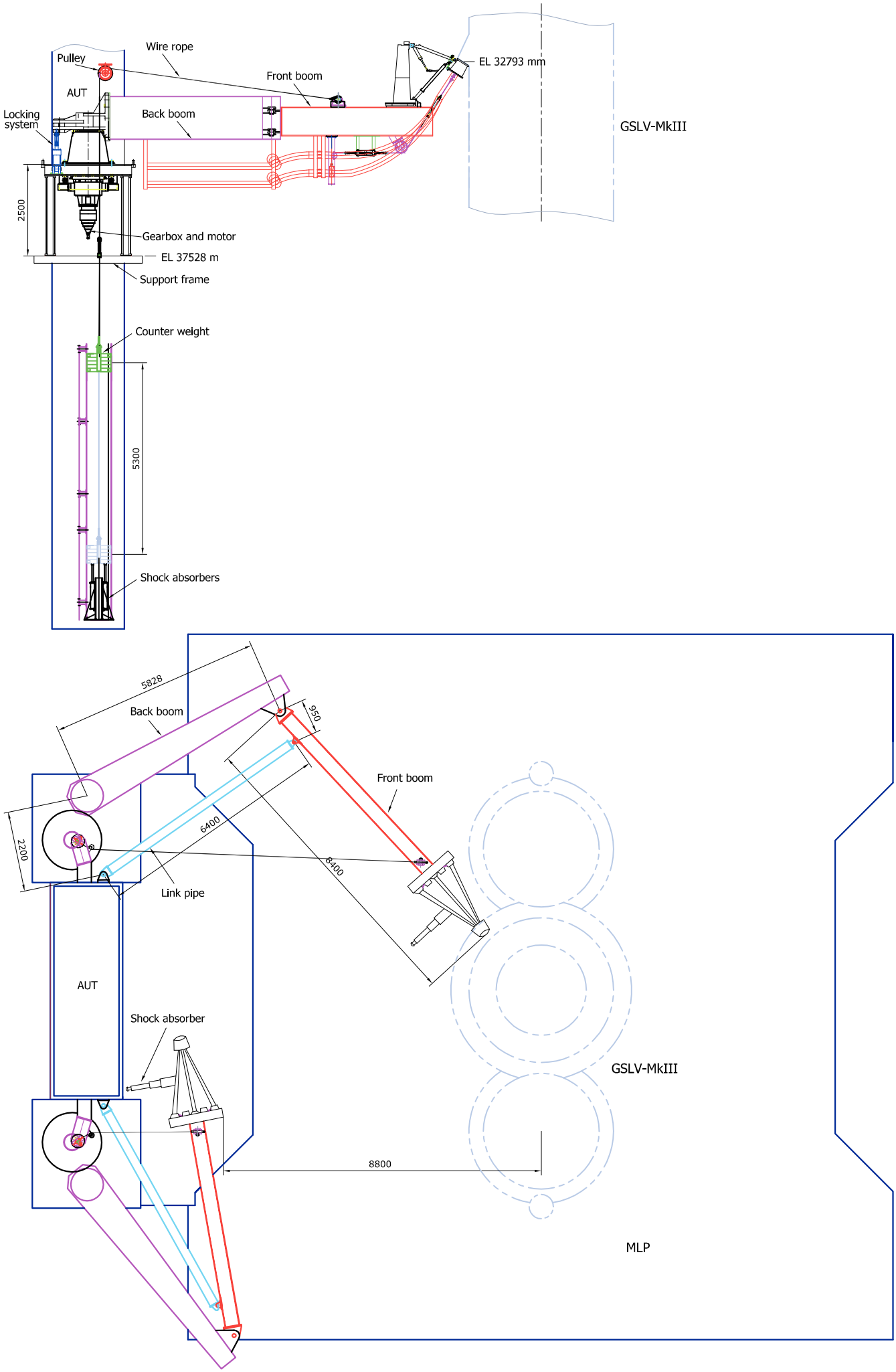


Fig. 12 Cryo arm on AUT (Counterweight actuation)

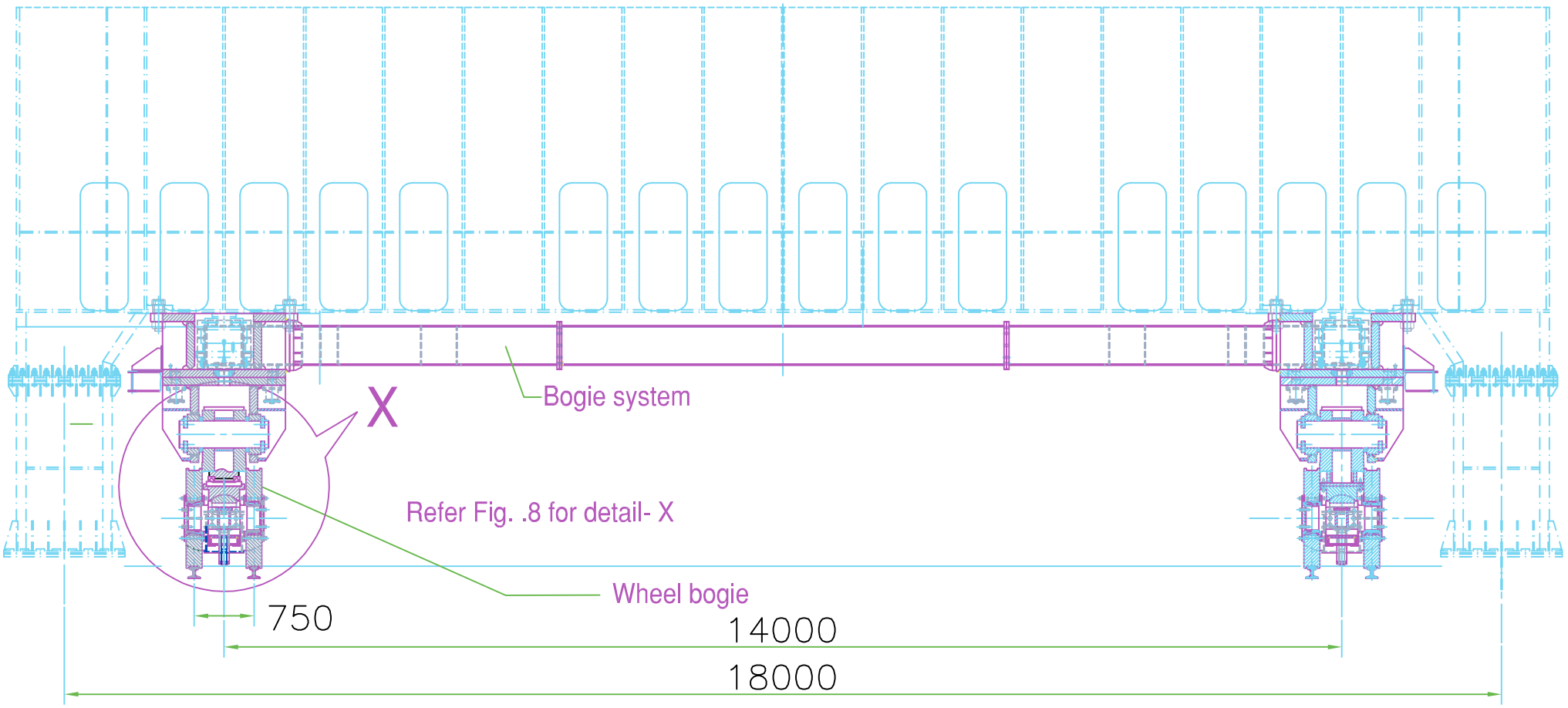


Fig. 13 Arrangement of MLP with bogie for curved track

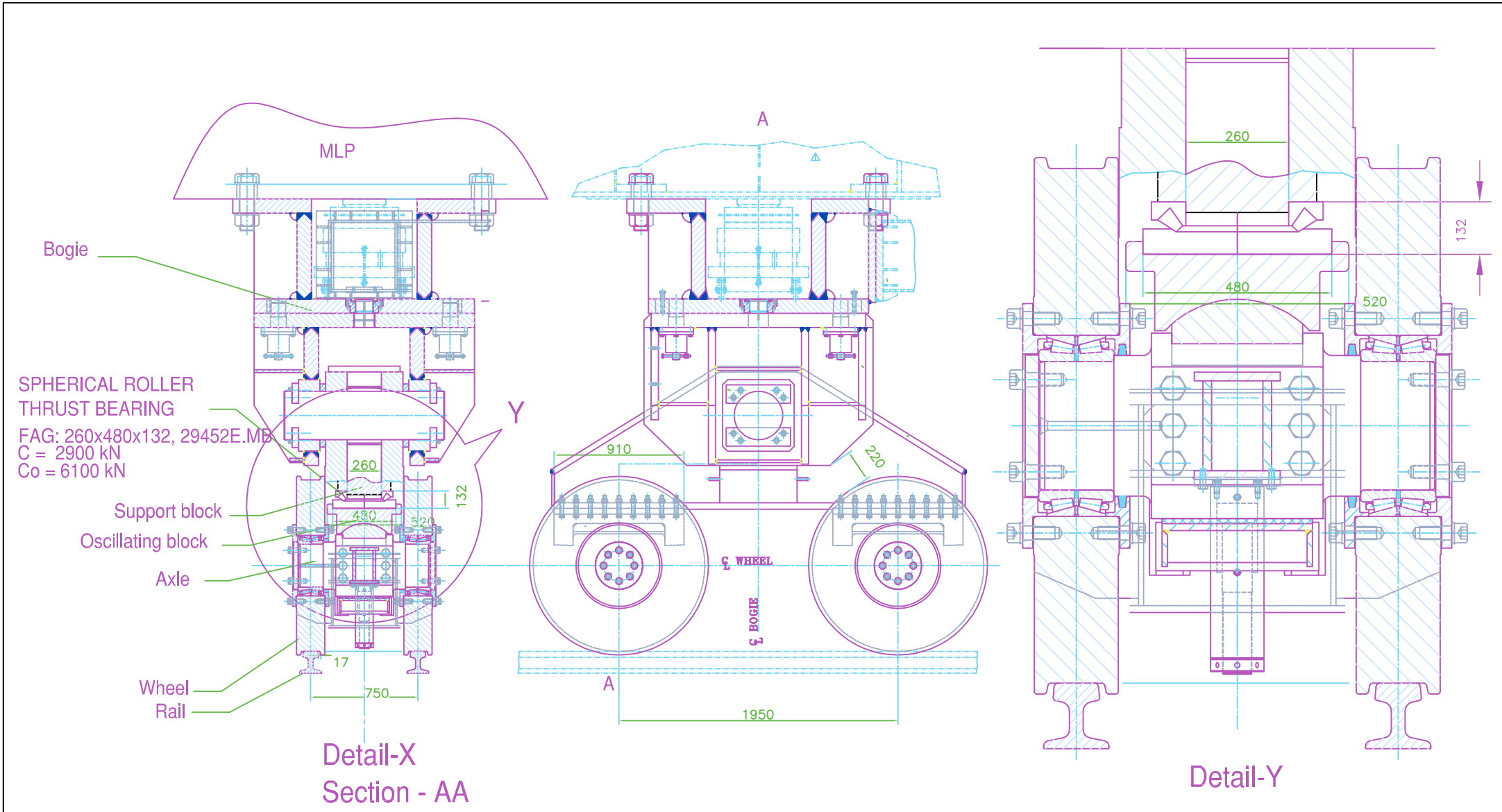


Fig 14 Wheel bogie arrangement

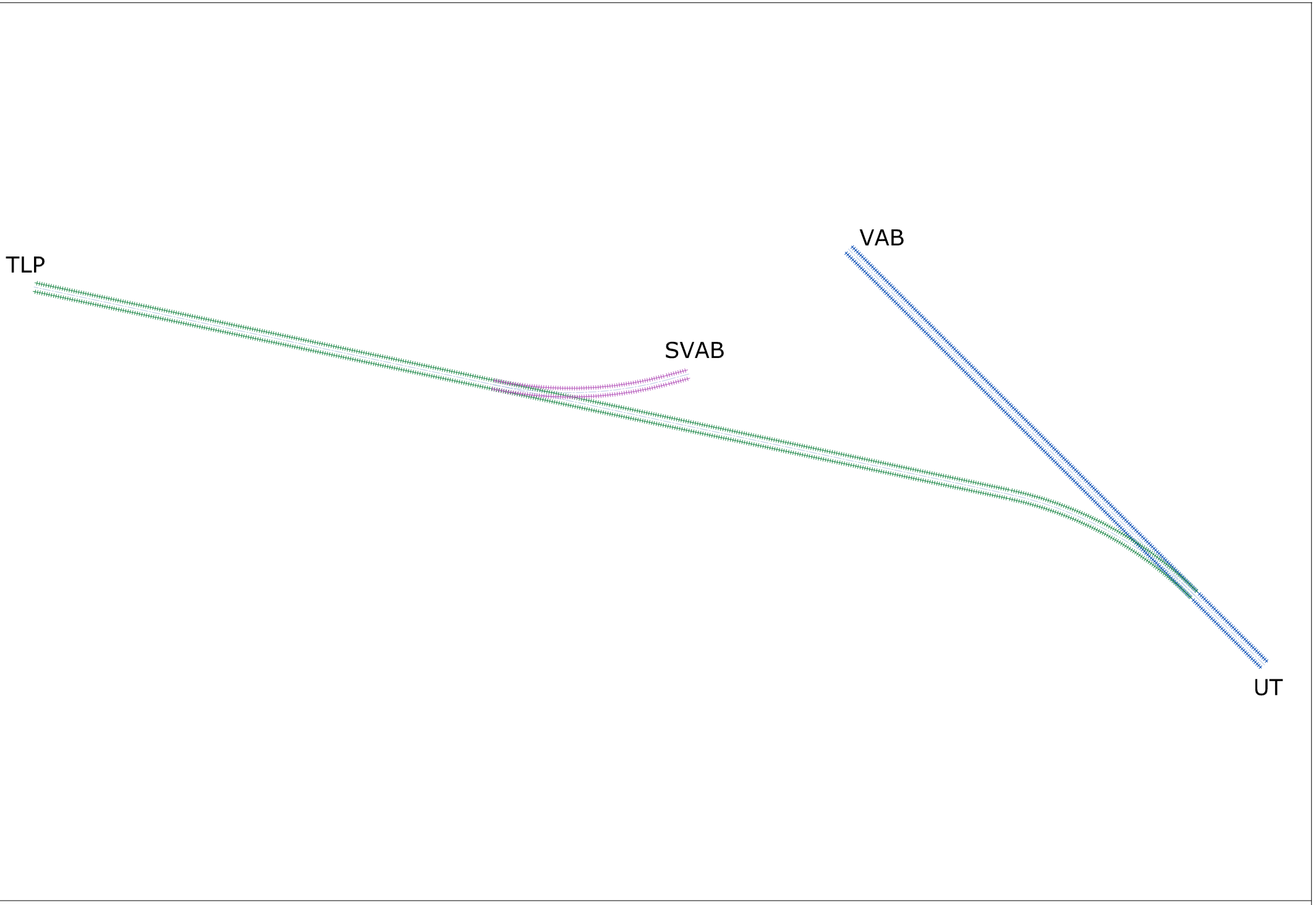


Fig. 15 Twin rail track from SVAB to UT

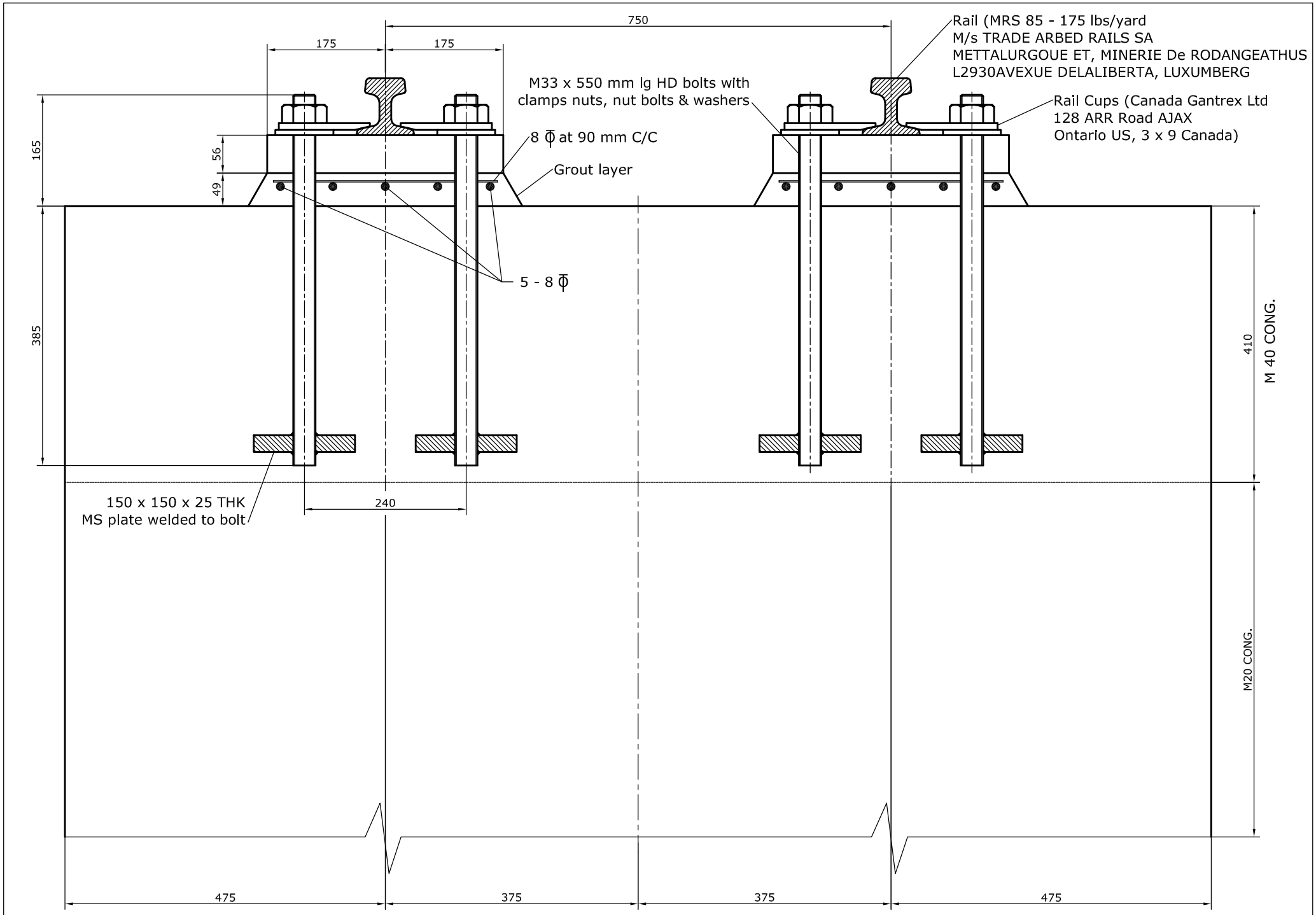


Fig. 16 Cross-section of MLP Track

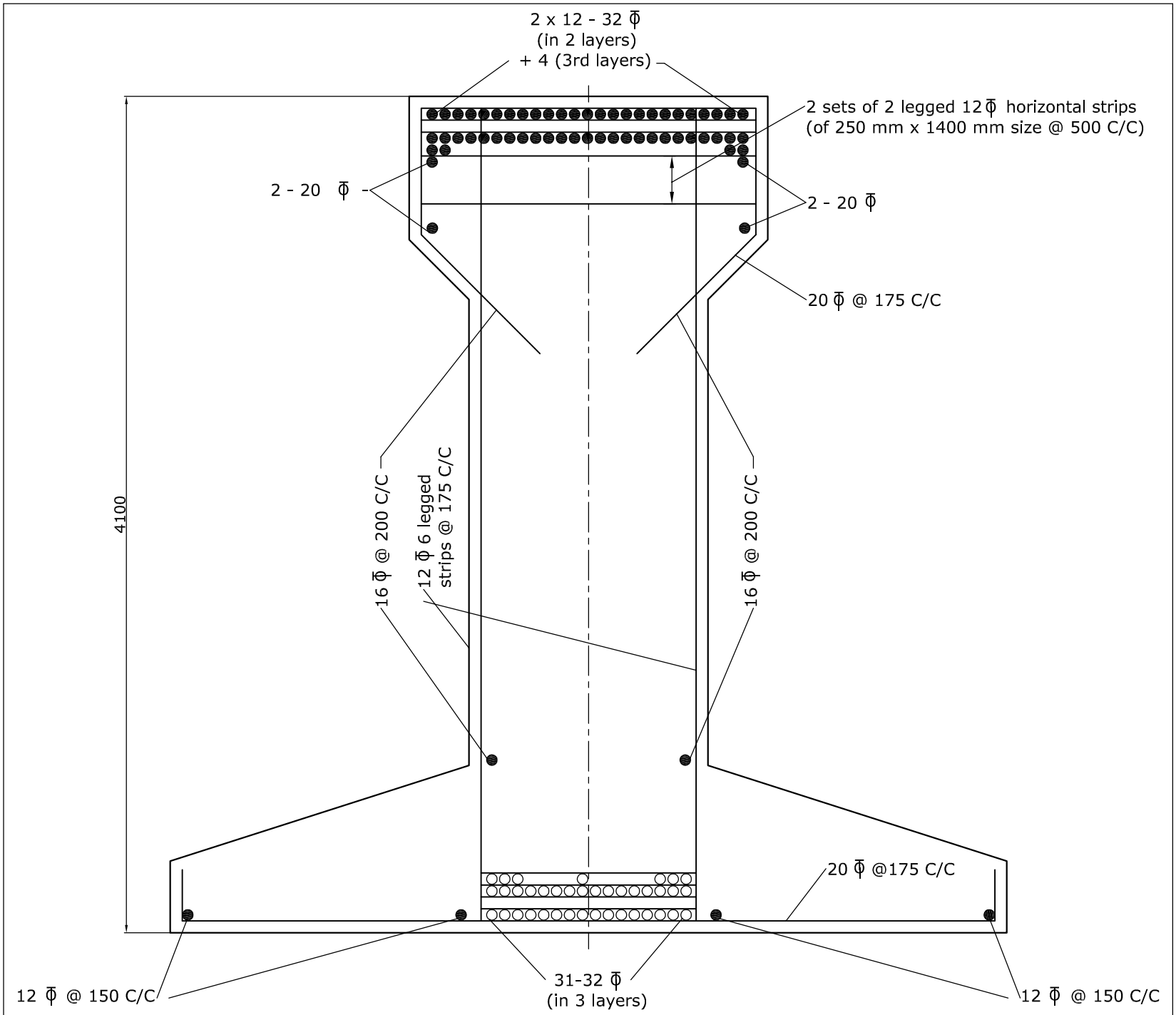
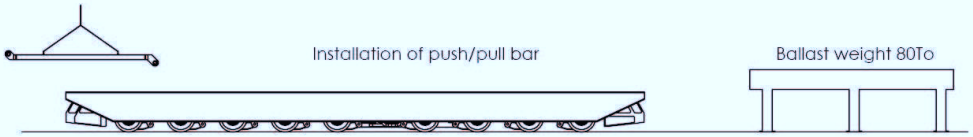
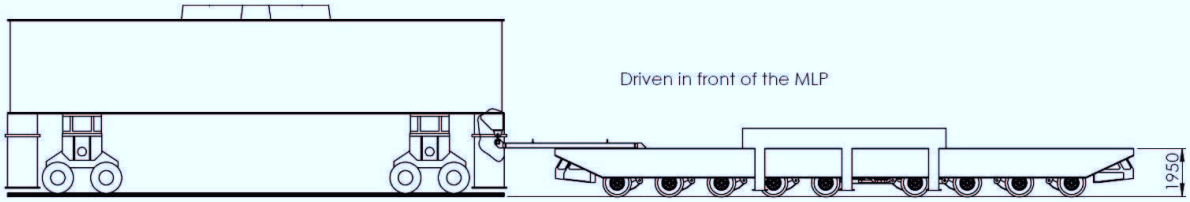
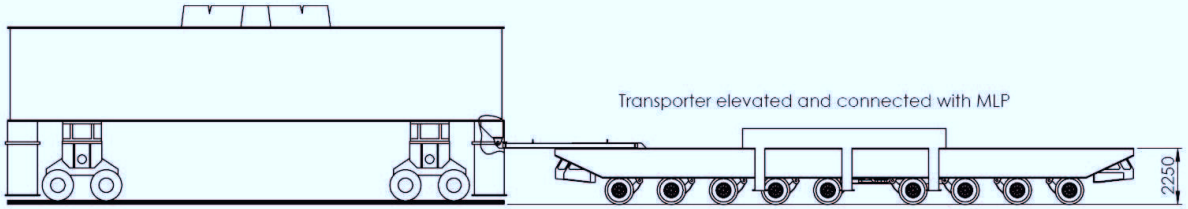
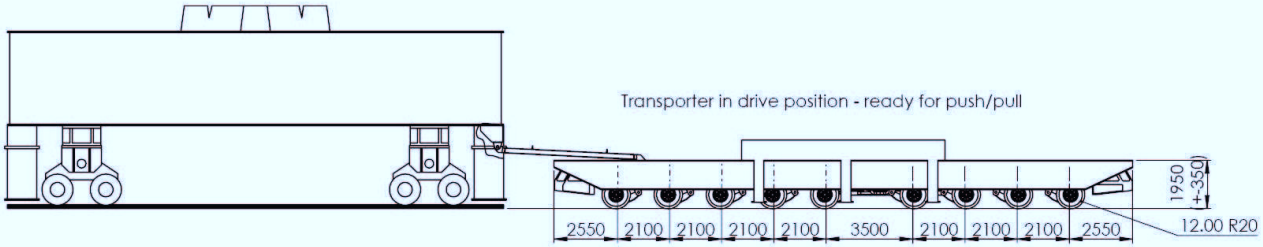


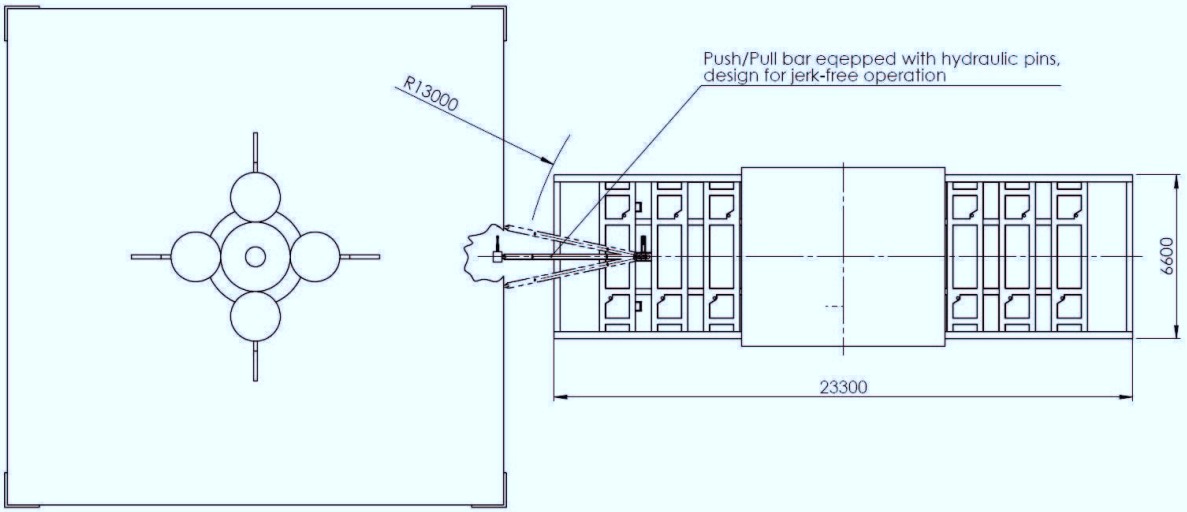
Fig. 17 Rail Track Foundation (Typ. RCC Cross section)

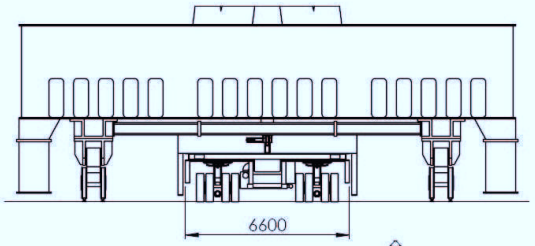

Installation of push/pull bar
Ballast weight 80To

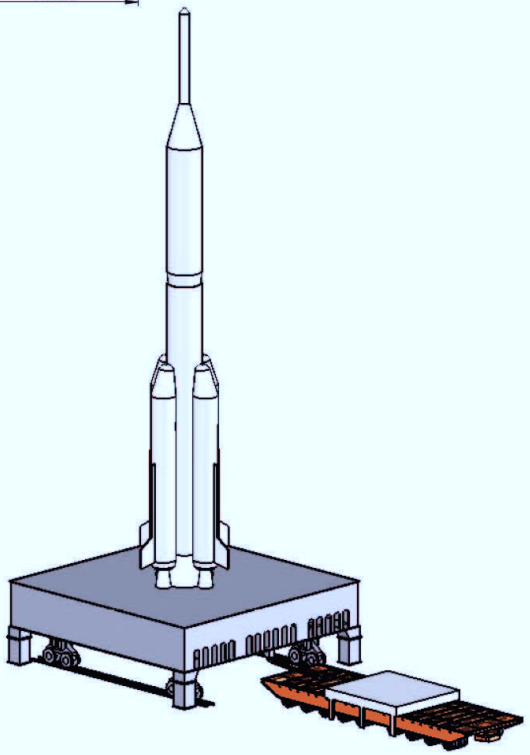

Driven in front of the MLP
1950


Transporter elevated and connected with MLP
2250


Transporter in drive position - ready for push/pull
1950 (+350)
2550
2100
2100
2100
2100
3500
2100
2100
2100
2550
12.00 R20


R13000
Push/Pull bar eqepped with hydraulic pins,
design for jerk-free operation
6600
23300


6600



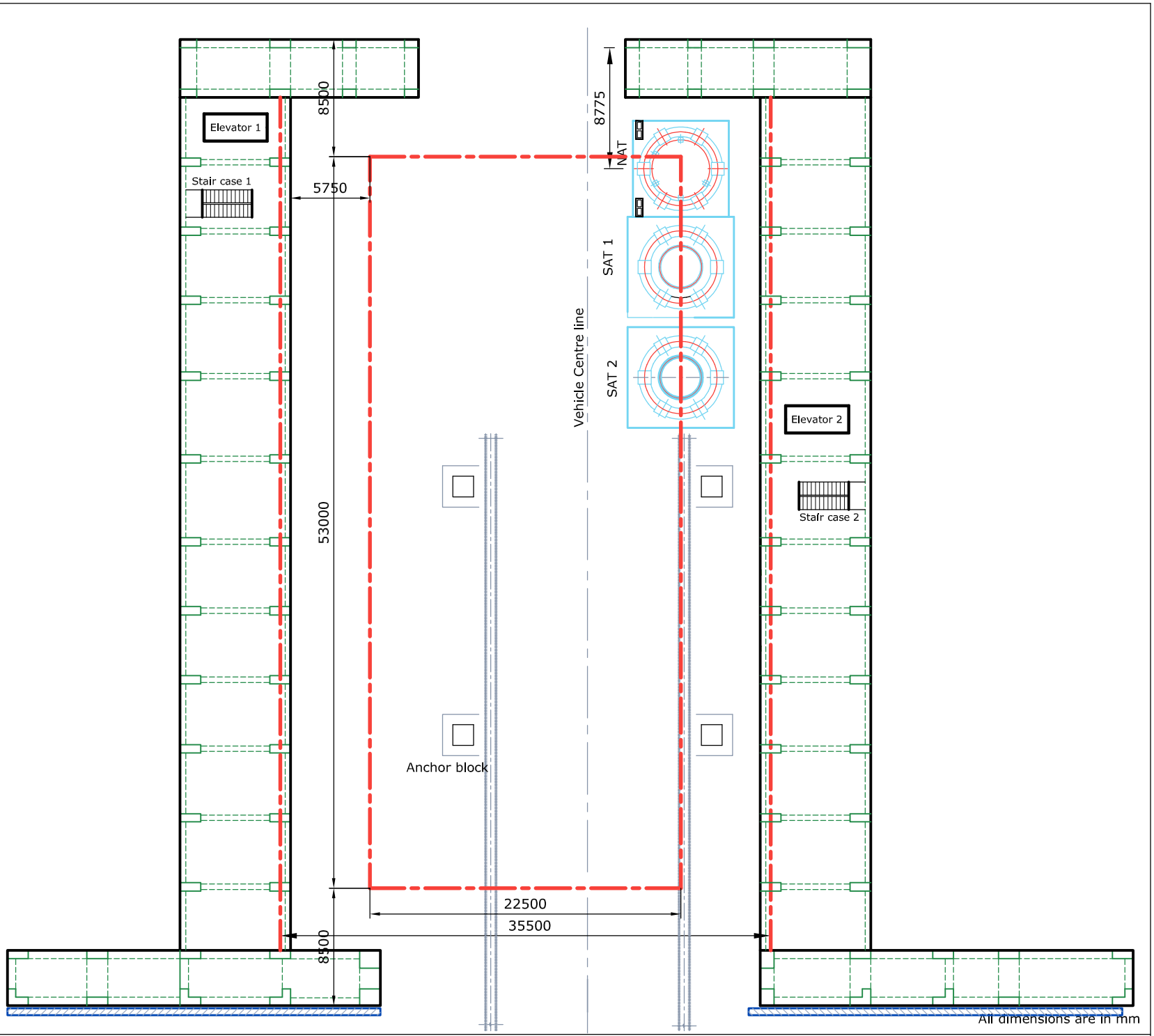


Fig 19 Crane approaches in SVAB